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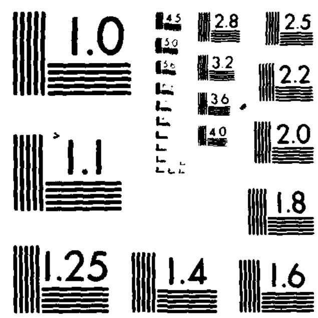
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CETA 82-1

Hand-Held Calculator Algorithms for Coastal Engineering

by

Todd L. Walton, Jr., William A. Birkemeier,

and J. Richard Weggel

COASTAL ENGINEERING TECHNICAL AID NO. 82-1

JANUARY 1982

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U.S. ARMY, CORPS OF ENGINEERS

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation. Six programs are included with different versions for use with hand-held calculators which employ either the Reverse Polish Notation (RPN) or the Algebraic Operating System (AOS). These programs can be used to compute linear wave parameters, orbital velocities, breaking wave height and direction, shallow-water wave forecasts, depth-limited breaking wave height, and wave transmission past a vertical barrier.

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PREFACE

This report provides coastal engineers algorithms for a number of hand-held calculator programs for coastal engineering, primarily in the area of wave transformations and wave generation. These algorithms were developed under the coastal engineering research program of the U.S. Army Coastal Engineering Research Center (CERC).

The report was written by Dr. Todd L. Walton, Jr., Hydraulic Engineer; William A. Birkemeier, Hydraulic Engineer; and Dr. J. Richard Weggel, Chief, Evaluation Branch, Engineering Development Division.

The authors acknowledge the assistance of A. Fromer and K. Stacy in preparing the manuscript. Reviews by R.A. Jachowski and Dr. R.J. Hallermeier of CERC and Dr. G. Oertel of Old Dominion University were appreciated.

Comments on this publication are invited.

Approved for publication ir ordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplc.ented by Public Law 172, 88th Congress, approved 7 November 1963.

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

CONTENTS

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: C = (5/9) (F -32).

To obtain Kelvin (K) readings, use formula: K = (5/9) (F -32) + 273.15.

HAND-HELD CALCULATOR ALGORITHMS FOR COASTAL ENGINEERING

by
Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel

I. INTRODUCTION

The advent of the hand-held programable calculator has led to the development of numerous programs in various fields of engineering and science. Coastal engineering is no exception. This report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation.

There are basically two types of hand-held programable calculators: those that use algebraic logic, such as Texas Instruments, Algebraic Operating System (AOS) notation, and those that use Reverse Polish Notation (RPN), such as Hewlett-Packard. For the six programs presented herein, versions in each type of notation are provided--AOS designated by "A" and RPN designated by "R." Each program is documented, the assumptions are briefly described, and references to more detailed presentations of the theory are given.

Since subtle differences exist among various brands of calculators and among various models by the same manufacturer, the programs presented may need to be modified to adapt them to other brands or models. These programs were prepared and checked, using the Texas Instruments TI-59 (AOS) and the Hewlett-Packard HP67 (RPN). Users should refer to the operating manuals supplied with individual calculators. Algorithms may be set up specifically to meet some limiting conditions. For example, some programable calculators have a limiting restriction on the number of program steps accepted so a program must be revised to meet the limitation. The Texas Instruments TI-57, for example, accepts only 50 program steps. Algorithms may be adapted to meet this limitation by requiring prior calculation of input parameters either manually or by another program.

Each of the AOS programs incorporates TI-59 compatible print routines which print and label all input and output parameters. The user only has to enter the input parameters and the results are automatically computed and printed. Since the printing routines increase program length by as much as 25 percent, use of a magnetic card for permanent program storage is recommended. All print steps are marked with asterisks and need not be entered if printing is not desired.

II. PROGRAMS

Six programs (100, 101, 102, 103, 104, and 105) are presented in this report. Program 100, a simple program that computes linear wave theory wavelength for a given depth, is designed to be used as the basis for any program that requires wavelength; in fact, it has been incorporated into programs 101, 102, and 105.

Program 101 is another basic program which computes not only wavelength but also a number of other linear wave theory parameters. This program forms the basis for program 102 and can be adapted to other programs as well.

Program 102 computes linear wave parameters and breaking wave height and direction based on nearshore or deepwater wave information. Program 103 can be used to forecast wave height and period in shallow water. Program 104 and 105 address wave conditions at structures--program 104 predicts the depth-limited design breaking wave height at a structure; 105 uses Fuch's equation to predict wave transmission over a thin barrier.

Each program allows either English or metric input and output (the AOS programs print an "M" when metric is selected). Program listings are annotated, making it possible to follow the logic of the algorithm and to make modifications if desired.

There are undoubtedly many calculator programs not included here that have been developed on coastal engineering subjects. Practicing engineers who would like to disseminate such programs (in either AOS or RPN) to other users are encouraged to submit them to the Coastal Engineering Research Center (CERC). If the response is great enough, additional reports presenting the programs will be prepared. Comments, programs, or suggestions for programs should be sent to:

Commander and Director
US Army Coastal Engineering Research Center
ATTN: Evaluation Branch
Kingman Building
Fort Belvoir, VA 22060

These programs and future programs will generally correspond to the following numbering scheme:

Miscellaneous	0-99
Waves and currents	100-299
Inlets	300-499
Beaches	500-699
Geology	700-899
Structures	900-1099

In general, the documentation of programs submitted should be in a format paralleling that of the programs presented in this report. A blank set of forms which can be reproduced is included in the Appendix.

Program Description

Program Title 100R Linear Wave Theory Wavelength (RPN logic)
Name J.R. Weggel **Date** 12/80
Address Coastal Engineering Research Center
Kingman Building
City Fort Belvoir, **State** Virginia **Zip Code** 22060

Program Description, Equations, Variables, etc.

This algorithm takes deepwater wavelength as input and using the depth at a given site iterates to obtain wavelength by linear wave theory. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Eq. (2-4), Stock No. 008-002-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

100R-1

User Instructions

Program Title: 100R Linear Wave Theory Wavelength (RPN logic)

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
	TO COMPUTE WAVELENGTH IN FEET				
1	ENTER WAVE PERIOD T (SEC)	T(SEC)	A		T(SEC)
2	READ Lo (FT)				Lo (FT)
3	ENTER DEPTH d (FT)	d (FT)	C		d (FT)
4	READ L (FT)				L (FT)
	FOR NEW DEPTH GO TO STEP 3				
	TO COMPUTE WAVELENGTH IN METERS				
1	ENTER WAVE PERIOD T (SEC)	T(SEC)	f	a	T(SEC)
2	READ Lo (M)				Lo (M)
3	ENTER DEPTH d (M)	d(M)	C		d (M)
4	READ L (M)				L(M)
	FOR NEW DEPTH GO TO STEP 3				
	EXAMPLE:				
	COMPUTE WAVE LENGTH OF 10 SECOND				
	WAVE IN 10 FEET OF WATER.				
	ENTER T = 10 SEC, PRESS A	10 (SEC)	A		
	READ Lo = 512.48 (FT)				512.48
	ENTER DEPTH d = 10 (FT)	10(FT)	C		
	READ L = 175.77 (FT)				175.77

100R-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	ENTER T
	STO 7	33 07	T → R_7
	3	03	
	2	02	
	•	83	
	2	02	
	STO 6	33 06	g (ENGLISH) → R_6
	f LBL B	31 25 12	
	RCL 7	34 07	
010	g x^2	32 54	
	RCL 6	34 06	
	x	71	
	2	02	
	÷	81	
	h π	35 73	
	÷	81	
	STO 1	33 01	L_o → R_1
	R/S	84	
	f LBL C	31 25 13	
020	2	02	
	x	71	
	h π	35 73	
	x	71	
	STO 5	33 05	$2\pi d$ → R_5
	RCL 1	34 01	
	f LBL D	31 25 14	
	STO 3	33 03	
	h 1/x	35 62	
	RCL 5	34 05	
030	x	71	
	STO 4	33 04	$\frac{2\pi d}{L_{od}}$ → R_4
	g e^x	32 52	
	RCL 4	34 04	
	CHS	42	
	g e^x	32 52	
	−	51	
	RCL 4	34 04	
	g e^x	32 52	
	RCL 4	34 04	
040	CHS	42	
	g e^x	32 52	
	+	61	tanh $\frac{2\pi d}{L_{od}}$
	÷	81	
	RCL 1	34 01	
	x	71	
	RCL 3	34 03	
	+	61	
	2	02	
	÷	81	
050	STO 2	33 02	
	RCL 3	34 03	
	−	51	
	h ABS	35 64	
	1	01	
	g x > y	32 81	
	GTO E	22 15	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	RCL 2	34 02	
	GTO D	22 14	
	f LBL E	31 25 15	
060	RCL 2	34 02	
	R/S	84	
	g LBL f a	32 25 11	PORTION OF PROGRAM NEEDED FOR METRIC
	STO 7	33 07	
	9	09	
	•	83	
	8	08	
	1	01	
	STO 6	33 06	
	GTO B	22 12	
070			
080			
090			
100			
110			

100R-3

Program Description

Program Title	100A Linear Wave Theory Wavelength (AOS logic)				
Name	J.R. Weggel			**Date**	12/80
Address	Coastal Engineering Research Center				
City	Kingman Building Fort Belvoir,	**State**	Virginia	**Zip Code**	22060

Program Description, Equations, Variables, etc.

This algorithm takes deepwater wavelength as input and using the depth at a given site iterates to obtain wavelength by linear wave theory. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Eq. (2-4), Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

100A-1

User Instructions

Program Title: 100A Linear Wave Theory Wavelength (AOS logic)

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
	TO COMPUTE WAVELENGTH				
1	ENTER WAVE PERIOD T(SEC)	T(SEC)	A		Lo(ft)
	PRESS A FOR ENGLISH UNITS	OR			
	OR PRESS A' FOR METRIC UNITS	T(SEC)	2nd	A'	Lo(m)
2	READ Lo(ft or m)				
3	ENTER DEPTH d(ft or m)	d(ft or m)	B		L(ft or m)
4	READ L(ft or m)				
	TO REPEAT FOR NEW DEPTH GO TO STEP 3				
	EXAMPLE:				
	COMPUTE THE WAVELENGTH OF 10 SECOND WAVE IN				
	10 FEET OF WATER				
	ENTER T= 10 SEC PRESS A	10 SEC	A		
	READ Lo = 512.48(ft)				512.48
	ENTER DEPTH d = 10(Ft)	10 ft	B		
	READ L= 175.773 (ft)				175.773
	NOTE: COMPUTATION OF L REQUIRES ABOUT 16SEC				
	PRINTOUT OF EXAMPLE				

```
          10.      T
 512.4789168      LO

          10.      D
 175.7737794       L
```

100A-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
000	LBL	76	
001	A	11	
002	STO	42	$T \rightarrow R_7$
003	07	07	
004	3	03	
005	2	02	
006	.	93	
007	2	02	
008	STO	42	$g_{ENGLISH} \rightarrow R_6$
009	06	06	
010	LBL	76	
011	B'	17	
012	3 *	03	
013	7 *	07	"T" PRINT CODE
014	OP *	69	
015	04 *	04	
016	RCL	43	
017	07	07	
018	OP *	69	
019	06 *	06	PRINT T
020	X^2	33	
021	×	65	
022	RCL	43	$L_0 = gT^2/2\pi$
023	06	06	
024	÷	55	
025	2	02	
026	÷	55	
027	π	89	
028	=	95	
029	STO	42	$L_0 \rightarrow R_{01}$
030	01	01	
031	2 *	02	
032	7 *	07	"L_0" PRINT CODE
033	3 *	03	
034	2 *	02	
035	OP *	69	
036	04 *	04	
037	RCL *	43	
038	01 *	01	
039	OP *	69	PRINT L_0
040	06 *	06	
041	R/S	91	
042	LBL	76	ENTER d
043	B	12	
044	ADV *	98	
045	X:T	32	
046	1 *	01	
047	6 *	06	"d" PRINT CODE
048	OP *	69	
049	04 *	04	
050	1	01	
051	X:T	32	
052	OP *	69	PRINT d
053	06	06	
054	×	65	
055	2	02	
056	×	65	
057	π	89	
058	=	95	
059	STO	42	$2\pi d \rightarrow R_{00}$
060	00	00	
061	RCL	43	
062	01	01	
063	LBL	76	
064	D'	19	
065	STO	42	$L_{OLD} \rightarrow R_3$
066	03	03	
067	1/X	35	
068	×	65	
069	RCL	43	
070	00	00	
071	=	95	
072	STO	42	$2\pi d/L_{OLD} \rightarrow R_4$
073	04	04	
074	INV	22	
075	LNX	23	
076	-	75	
077	EXC	48	
078	04	04	
079	+/-	94	
080	INV	22	
081	LNX	23	
082	STO	42	
083	05	05	
084	=	95	
085	÷	55	
086	(	53	
087	RCL	43	
088	04	04	
089	+	85	
090	RCL	43	
091	05	05	
092	=	95	tanh $2\pi d/L_{OLD}$
093	×	65	
094	RCL	43	
095	01	01	
096	+	85	
097	RCL	43	
098	03	03	
099	=	95	
100	÷	55	
101	2	02	
102	=	95	
103	STO	42	$L_{NEW} \rightarrow R_2$
104	02	02	
105	-	75	
106	RCL	43	

100A-3

* DELETE IF PRINTER IS NOT AVAILABLE

STEP	KEY ENTRY	KEY CODE	COMMENTS
107	03	03	
108	=	95	
109	I×I	50	
110	INV	22	
111	GE	77	
112	C'	18	
113	RCL	43	
114	02	02	
115	D'	19	
116	LBL	76	
117	C'	18	
118	2 *	02	"L" PRINT CODE
119	7 *	07	
120	OP *	69	
121	04 *	04	
122	RCL	43	
123	02	02	
124	OP *	69	PRINT L
125	06 *	06	
126	R/S	91	L IN DISPLAY
127	LBL	76	ROUTINE TO PUT g = 9.81 INTO R_6 FOR METRIC CALCULATIONS
128	A'	16	
129	STO	42	
130	07	07	
131	9	09	
132	.	93	
133	8	08	
134	1	01	
135	STO	42	
136	06	06	
137	3 *	03	DELETE IF ONLY ENGLISH UNITS ARE TO BE PROCESSED
138	0 *	00	
139	OP *	69	
140	04 *	04	
141	OP *	69	
142	05 *	05	
143	B'	17	

100A-4

Program Description

Program Title 101R Calculation of Wave Parameters from Linear Theory (RPN logic)

Name T.L. Walton, Jr. **Date** 12/80
Address Coastal Engineering Research Center
Kingman Building
City Fort Belvoir, **State** Virginia **Zip Code** 22060

Program Description, Equations, Variables, etc.

This program calculates the product of the wave number and depth, kd, the ratio of group wave speed to wave celerity, n = 0.5 (1+2kd/sinh 2kd), the group wave speed, Cg, the shoaling coefficient, K_s, the refraction coefficient, K_r, horizontal orbital velocity, u, and vertical orbital velocity, w.

Program input includes wave period, T, deepwater wave angle, α_o, deepwater wave height, H_o, wave phase angle, θ, depth of water, d, at which results are desired, and depth from surface, z, at which velocities are calculated. This program assumes straight and parallel offshore bottom contours for assumption of Snell's law of refraction. Algorithm uses English or metric system of units.

REFERENCES

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings This program can also be used for wave input H, T, and α, from transitional water depths (as in the case when wave gage information is provided but the gage is not in deep water). In this instance, some program steps must be deleted as noted in the program listing, and the K_r computed in the program is *not* the refraction coefficient for depth, d, but a *modified* refraction coefficient from the gage site to water depth, d.

101R-1

User Instructions

Program Title: 101R Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
	TO COMPUTE WAVE PARAMETERS				
	IF DESIRED TO CALCULATE ORBITAL				
	VELOCITIES U, W AT A SPECIFIED				
	PHASE ANGLE, "θ", INCLUDE				
	THE FOLLOWING STEPS:				
1	ENTER Ho (FT OR M) IN DISPLAY *	Ho (FT OR M)			
2	PRESS STO 8, STORING H IN R8		STO	8	
3	ENTER Z (FT OR M) IN DISPLAY	Z (FT OR M)			
4	PRESS STO B, STORING Z IN RB		STO	B	
5	ENTER θ (DEGREES) IN DISPLAY	θ (DEGREES)			
6	PRESS STO E, STORING θ IN RE		STO	E	
	IF U AND W ARE NOT DESIRED the				
	FOREGOING STEPS CAN BE OMITTED				
7	ENTER WAVE PERIOD T (SEC)	T (SEC)	A		T
8	ENTER DEPTH d (METERS OR FT)	d (FT OR M)	B		2π d
9	ENTER DEEPWATER WAVE ANGLE				
	αo (DEGREES)	αo (DEG)	C		SIN α
10	PRESS E TO COMPUTE WAVE PARAMETERS		E		ENGLISH
	IN ENGLISH UNITS OR;				
	PRESS D FOR METRIC UNITS		D		METRIC
11	READ Kd IN DISPLAY				Kd
12	PRESS R/S AND READ n		R/S		n
13	PRESS R/S AND READ Cg (FT OR M)		R/S		Cg (FT OR M)
14	PRESS R/S AND READ Ks		R/S		Ks
15	PRESS R/S AND READ Kr		R/S		Kr
16*	PRESS R/S AND READ H (FT OR M) *		R/S		H (FT OR M)
17	PRESS R/S AND READ U (FT/SEC OR M/SEC)		R/S		U (F/S OR M/S)
18	PRESS R/S AND READ W (FT/SEC OR M/SEC)		R/S		W (F/S OR M/S)
	SEE EXAMPLE, NEXT PAGE				
	* IF WAVE HEIGHT H AT DEPTH d				
	IS ENTERED, DELETE STEPS				
	WITH ASTERISK *.				

101R-2

User Instructions

Program Title: 101R Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
	EXAMPLE				
	H_0 = 18 FT, Z = -15 FT, θ = 60°				
	T = 8 SEC, d = 50 FT, α_0 = 30°				
	ENTER H_0 = 18, PRESS STO 8	18	STO	8	18.00
	ENTER Z = -15, PRESS STO B	-15	STO	B	-15.00
	ENTER θ = 60°, PRESS STO E	60	STO	E	60.00
	ENTER T = 8 SEC., PRESS A		A		8.00
	ENTER d = 50 FT., PRESS B		B		314.00
	ENTER α_0 = 30°, PRESS C		C		0.50
	PRESS E, READ Kd = 1.16		E		1.16
	PRESS R/S, READ Ω = 0.73		R/S		0.73
	PRESS R/S, READ Cg = 24.62 FT/SEC		R/S		24.62
	PRESS R/S, READ Ks = 0.91		R/S		0.91
	PRESS R/S, READ Kr = 0.97		R/S		0.97
	PRESS R/S, READ H = 16.01 FT. *		R/S		16.01
	PRESS R/S, READ U = 2.94 FT/SEC		R/S		2.94
	PRESS R/S, READ W = 3.43 FT/SEC		R/S		3.43

101R-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	
	STO 2	33 02	$T \rightarrow R_2$
	R/S	84	
	f LBL B	31 25 12	
	h π	35 73	
	x	71	
	2	02	
	x	71	
	STO 1	33 01	$2\pi d \rightarrow R_1$
010	R/S	84	
	f LBL C	31 25 13	
	f SIN	31 62	
	STO 0	33 00	$\text{SIN } \alpha_0 \rightarrow R_0$
	R/S	84	
	f LBL D	31 25 14	
	9	09	
	•	83	
	8	08	
	1	01	
020	STO D	33 14	$g(\text{METRIC}) \rightarrow R_D$
	f GSB 0	31 22 00	
	GTO f a	22 31 11	
	f LBL E	31 25 15	
	3	03	
	2	02	
	•	83	
	2	02	
	STO D	33 14	$g(\text{ENGLISH}) \rightarrow R_D$
	f GSB 0	31 22 00	
030	g LBL f a	32 25 11	
	2	02	
	x	71	
	STO A	33 11	$\frac{4\pi d}{L} \rightarrow R_A$
	f GSB 1	31 22 01	
	h 1/x	35 62	
	RCL A	34 11	
	x	71	
	1	01	
	+	61	
040	2	02	
	÷	81	
	STO A	33 11	$n \rightarrow R_A$
	R/S	84	n IN DISPLAY
	RCL 4	34 04	
	x	71	
	RCL 2	34 02	
	÷	81	
	R/S	84	C_g IN DISPLAY
	h 1/x	35 62	
050	RCL 2	34 02	
	x	71	
	RCL D	34 14	
	x	71	
	4	04	
	÷	81	
	h π	35 73	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	÷	81	
	f √x	31 54	
	STO A	33 11	$K_s = \sqrt{C_{go}/C_g} \rightarrow R_A$
060	R/S	84	K_s IN DISPLAY
	RCL 0	34 00	
	RCL 1	34 01	
	x	71	
	RCL 3	34 03	
	÷	81	K_{od} SIN α_0
	RCL 9	34 09	
	÷	81	SIN α
	g x²	32 54	
	1	01	
070	−	51	
	CHS	42	$\cos^2 \alpha$
	h 1/x	35 62	
	1	01	
	ENTER	41	
	RCL 0	34 00	
	g x²	32 54	
	−	51	
	x	71	
	f √x	31 54	
080	f √x	31 54	
	h STI	35 33	$K_r \rightarrow R_1$
	R/S	84	K_r IN DISPLAY
	g LBL f b	32 25 12	
	RCL 8	34 08	
	h RCI *	35 34	
	x *	71	
	RCL A *	34 11	
	x *	71	
	R/S *	84	
090	RCL D	34 14	
	x	71	
	RCL 2	34 02	
	x	71	
	2	02	
	÷	81	
	RCL 4	34 04	
	÷	81	
	RCL 6	34 06	
	÷	81	
100	STO 8	33 08	$\frac{H}{2} \frac{gT}{L} \frac{1}{\cosh \frac{2\pi d}{L}} \rightarrow R_B$
	RCL 1	34 01	
	2	02	
	÷	81	
	h π	35 73	
	÷	81	
	RCL B	34 12	
	+	61	
	2	02	
	x	71	
110	h π	35 73	
	x	71	
	RCL 4	34 04	

101R-4

* DELETE THESE STEPS IF ENTERED WAVE HEIGHT IS AT DEPTH d

STEP	KEY ENTRY	KEY CODE	COMMENTS
	÷	81	$\frac{2\pi(z+d)}{L} \to R_5$
	STO 5	33 05	
	f GSB 2	31 22 02	
	RCL 8	34 08	
	x	71	
	RCL E	34 15	
	f COS	31 63	
120	x	71	
	R/S	84	U IN DISPLAY
	RCL 5	34 05	
	f GSB 1	31 22 01	
	RCL 8	34 08	
	x	71	
	RCL E	34 15	
	f SIN	31 62	
	x	71	
	R/S	84	W IN DISPLAY
130	f LBL 0	31 25 00	SUB TO CALC. L
	RCL 2	34 02	
	g x^2	32 54	
	RCL D	34 14	
	x	71	
	2	02	
	÷	81	
	h π	35 73	
	÷	81	
	STO 3	33 03	$L_o \to R_3$
140	g LBL f d	32 25 14	
	STO A	33 11	$L_{OLD} \to R_A$
	h 1/x	35 62	
	RCL 1	34 01	
	x	71	$\frac{2\pi d}{L_{OLD}} \to R_C$
	STO C	33 13	
	f GSB 2	31 22 02	
	STO 6	33 06	$\cosh\left(\frac{2\pi d}{L_{OLD}}\right) \to R_6$
	RCL C	34 13	
	f GSB 1	31 22 01	
150	STO 5	33 05	$\sinh\left(\frac{2\pi d}{L_{OLD}}\right) \to R_5$
	RCL 6	34 06	
	÷	81	
	RCL 3	34 03	
	x	71	
	RCL A	34 11	
	+	61	
	2	02	
	÷	81	
	STO 4	33 04	$L_{NEW} \to R_A$
160	RCL A	34 11	
	−	51	
	h ABS	35 64	
	1	01	
	g x≥y	32 81	
	GTO f e	22 31 15	
	RCL 4	34 04	
	GTO f d	22 31 14	
	g LBL f e	32 25 15	
	RCL 1	34 01	
170	RCL 4	34 04	
	÷	81	
	STO 9	33 09	$Kd \to R_9$
	R/S	84	
	h RTN	35 22	SUB sinh ( )
	f LBL 1	31 25 01	
	STO 7	33 07	
	g e^x	32 52	
	RCL 7	34 07	
	CHS	42	
180	g e^x	32 52	
	−	51	
	2	02	
	÷	81	
	h RTN	35 22	
	f LBL 2	31 25 02	
	STO 7	33 07	
	g e^x	32 52	
	RCL 7	34 07	
	CHS	42	
190	g e^x	32 52	
	+	61	
	2	02	
	÷	81	
	h RTN	35 22	SUB cosh ( )
200			
210			
220			

101R-5

Program Description

Program Title	101A Calculation of Wave Parameters from Linear Theory (AOS logic)
Name	W.A. Birkemeier **Date** 5/81
Address	CERC Field Research Facility
City	Kitty Hawk, **State** North Carolina **Zip Code** 27949

Program Description, Equations, Variables, etc.

This program calculates the product of the wave number and depth, kd, the ratio of group wave speed to wave celerity, $n = 0.5\ (1+2kd/\sinh 2kd)$, the group wave speed, Cg, the shoaling coefficient, K_s, the refraction coefficient, K_r, horizontal orbital velocity, u, and vertical orbital velocity, w.

Program input includes wave period, T, deepwater wave angle, α_o, deepwater wave height, H_o, wave phase angle, θ, depth of water, d, at which results are desired, and depth from surface, z, at which velocities are calculated. This program assumes straight and parallel offshore bottom contours for assumption of Snell's law of refraction. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings This program can also be used for wave input H, T, and α, from transitional water depths (as in the case when wave gage information is provided but the gage is not in deep water). In this instance, some program steps must be deleted as noted in the program listing, and the K_r computed in the program is *not* the refraction coefficient for depth, d, but a *modified* refraction coefficient from the gage site to water depth, d.

101A-1

User Instructions

Program Title: 101A Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
	TO COMPUTE WAVE PARAMETERS				
1	ENTER WAVE PERIOD T(SEC)	T (SEC)	A		T
2	ENTER DEPTH d (ft OR m)	d	B		2nd
3	ENTER DEEPWATER WAVE ANGLE	α_0 (deg)	C		$\sin \alpha_0$
4	PRESS E to COMPUTE WAVE		E		
	PARAMETERS (ENGLISH UNITS) OR PRESS D FOR		D		
	METRIC UNITS				
	NOTE: WITH A PRINTER Kd, n, Cg, Ks,	Kr			
	ARE PRINTED AND LABELED IN ABOUT 20 SEC,				
	OTHERWISE:				
5	READ Kd IN DISPLAY				Kd
6	PRESS R/S AND READ n		R/S		n
7	PRESS R/S AND READ Cg (ft/SEC OR M/SEC)		R/S		Cg
8	PRESS R/S AND READ Ks		R/S		Ks
9	PRESS R/S AND READ Kr		R/S		Kr
	TO REPEAT, ENTER NEW VALUE USING STEPS 1, 2, OR 3				
	AND STEP 4				
	TO COMPUTE WAVE ORBITAL VELOCITY, AFTER COMPLETING				
	THE ABOVE STEPS.				
A	ENTER DEEPWATER WAVE HEIGHT H_0 (ft OR m) PRESS A'	H_0	2nd	A'	
	NOTE: IF H, NOT H_0 IS KNOWN, DELETE PROGRAM				
	STEPS MARKED BY ●.				
	THEN ENTER H INSTEAD OF H_0.				
B	ENTER DEPTH BELOW STILL WATER	z	2nd	B'	
	(NEGATIVE ft OR M)				
C	COMPUTE AND ENTER THE PHASE ANGLE				
	$\theta = \left(\frac{2\pi x}{L} - \frac{2\pi t}{L}\right)$ IN DEGREES	θ (DEG)	2nd	C'	

101A-2

User Instructions

Program Title: 101A Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
	WITH PRINTER H, U, AND W ARE PRINTED IN				
	APPROPRIATE UNITS (VELOCITIES ARE IN ft/SEC				
	OR M/SEC) OTHERWISE:				
D	READ H IN DISPLAY (IF USING H NOT H_o,				H
	READ U IN DISPLAY AND PROCEED TO STEP F)				
E	PRESS R/S AND READ U IN DISPLAY		R/S		U
F	PRESS R/S AND READ W IN DISPLAY		R/S		W
	TO REPEAT, START AT STEP C FOR NEW θ OR				
	WITH STEP A OR B AND THEN C.				

101A-3

User Instructions

Program Title: 101A Calculation of Wave Parameters from Linear Theory

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
	EXAMPLE : CALCULATE WAVE PARAMETERS FOR :				
	T = 8 sec				
	d = 50 ft				
	α_0 = 30°				
	H_0 = 18 ft				
	z = -15 ft				
	θ = 60°				
	ENTER T PRESS A	8 SEC	A		8
	ENTER d PRESS B	50 ft	B		314.15
	ENTER α_0 PRESS C	30°	C		0.5
	PRESS E TO COMPUTE		E		
	CALCULATED VALUES ARE PRINTED OR				
	READ Kd = 1.163				1.163
	PRESS R/S AND READ n = 0.729				0.729
	PRESS R/S AND READ C_g = 24.625 ft/sec				24.625
	PRESS R/S AND READ K_S = 0.912				0.912
	PRESS R/S AND READ K_r = 0.975				0.954
	ENTER H_0 PRESS A'	18 ft	2nd	A'	223.65
	ENTER z PRESS B'	-15 ft	2nd	B'	-94.25
	ENTER θ PRESS C'	60°	2nd	C'	
	CALCULATED VALUES ARE PRINTED OR:				
	READ H = 16.0 ft, PRESS R/S AND READ U = 2.944 ft/sec				2.944
	PRESS R/S AND READ W = 3.426 ft/sec				3.426
	EXAMPLE 8. T				
	PRINTOUT 50. D				
	30. ANGO				
	1.16314388 KD				
	0.729367164 N				
	24.62479667 CG				
	.9123924245 KS				
	.9748438618 KR				
	18. HO				
	-15. Z				
	60. PANG				
	16.00992278 H				
	2.943703553 U				
	3.42578442 W				

101A-4

Program Listing

STEP	KEY ENTRY	KEY CODE		COMMENTS
000	LBL	76		
001	A	11		
002	STO	42		$T \rightarrow R_2$
003	02	02		
004	3	03	*	
005	7	07	*	"T" PRINT CODE
006	OP	69	*	
007	04	04	*	
008	RCL	43	*	
009	02	02	*	
010	OP	69	*	PRINT T
011	06	06	*	
012	R/S	91		
013	LBL	76		
014	B	12		
015	STO	42		$d \rightarrow R_1$
016	01	01		
017	1	01	*	"D" PRINT CODE
018	6	06	*	
019	OP	69	*	
020	04	04	*	
021	RCL	43	*	
022	01	01	*	
023	OP	69	*	
024	06	06	*	PRINT d
025	×	65		
026	π	89		
027	×	65		
028	2	02		
029	=	95		
030	STO	42		$2\pi d \rightarrow R_{11}$
031	11	11		$2\pi d$ IN DISPLAY
032	R/S	91		
033	LBL	76		
034	C	13		
035	STO	42		$\alpha_0 \rightarrow R_0$
036	00	00		
037	1	01	*	
038	3	03	*	
039	3	03	*	"ANGO" PRINT CODE
040	1	01	*	
041	2	02	*	
042	2	02	*	
043	0	00	*	
044	1	01	*	
045	OP	69	*	
046	04	04	*	
047	RCL	43	*	
048	00	00	*	
049	OP	69	*	PRINT α_0
050	06	06	*	
051	SIN	38		
052	STO	42		$\sin \alpha_0 \rightarrow R_0$
053	00	00		
054	R/S	91		SIN α_0 IN DISPLAY
055	LBL	76		SUBROUTINE TO COMPUTE sin h (x)
056	SIN	38		
057	STO	42		
058	07	07		
059	INV	22		
060	LNX	23		
061	-	75		
062	RCL	43		
063	07	07		
064	+/-	94		
065	INV	22		
066	LNX	23		
067	=	95		
068	÷	55		
069	2	02		
070	=	95		
071	RTN	92		
072	LBL	76		
073	COS	39		SUBROUTINE TO COMPUTE cos h (x)
074	STO	42		
075	07	07		
076	INV	22		
077	LNX	23		
078	+	85		
079	RCL	43		
080	07	07		
081	+/-	94		
082	INV	22		
083	LNX	23		
084	=	95		
085	÷	55		
086	2	02		
087	=	95		
088	RTN	92		
089	LBL	76		
090	D	14		
091	9	09		ROUTINE TO ALLOW METRIC INPUT/OUTPUT
092	.	93		
093	8	08		
094	1	01		
095	STO	42		
096	13	13		DELETE IF UNWANTED
097	3	03	*	
098	0	00	*	
099	OP	69	*	$g = 9.81 \rightarrow R_{13}$
100	04	04	*	
101	OP	69	*	ROUTINE PRINTS AN "M" TO INDICATE METRIC
102	05	05	*	
103	GTO	61		
104	RCL	43		
105	LBL	76		
106	E	15		
107	3	03		

101A-5

* - DELETE IF PRINTER IS NOT AVAILABLE

STEP	KEY ENTRY	KEY CODE	COMMENTS
108	2	02	$g = 32.2\,ft/sec^2$
109	.	93	
110	2	02	
111	STO	42	
112	13	13	$\to R_{13}$
113	LBL	76	
114	RCL	43	
115	ADV	98	
116	1	01	
117	X:T	32	
118	RCL	43	1 → t register
119	02	02	
120	X²	33	
121	×	65	
122	RCL	43	
123	13	13	
124	÷	55	$L_0 = gT^2/2\pi$
125	2	02	
126	÷	55	
127	π	89	
128	=	95	
129	STO	42	$L_0 \to R_3$
130	03	03	
131	LBL	76	
132	D'	19	
133	STO	42	$L_{OLD} \to R_{10}$
134	10	10	
135	1/X	35	
136	×	65	
137	RCL	43	
138	11	11	
139	=	95	$\frac{2\pi d}{L_{OLD}} \to R_{12}$
140	STO	42	
141	12	12	
142	SBR	71	
143	COS	39	$\cosh\left(\frac{2\pi d}{L_{OLD}}\right) \to R_6$
144	STO	42	
145	06	06	
146	RCL	43	
147	12	12	
148	SBR	71	
149	SIN	38	
150	STO	42	$\sinh\left(\frac{2\pi d}{L_{OLD}}\right) \to R_5$
151	05	05	
152	÷	55	
153	RCL	43	
154	06	06	
155	×	65	
156	RCL	43	
157	03	03	
158	+	85	
159	RCL	43	
160	10	10	
161	=	95	

	STEP	KEY ENTRY	KEY CODE		COMMENTS
	162	÷	55		
	163	2	02		
	164	=	95		
	165	STO	42		
	166	04	04		$L_{NEW} \to R_4$
	167	-	75		
	168	RCL	43		
	169	10	10		
	170	=	95		
	171	I×I	50		ITERATE UNTIL
	172	INV	22		$L_{NEW} - L_{OLD} < t$
	173	GE	77		WHERE t IS VALUE
	174	E'	10		IN t REGISTER
	175	RCL	43		
	176	04	04		
	177	D'	19		
	178	LBL	76		
	179	E'	10		
	180	RCL	43		
	181	11	11		
	182	÷	55		
	183	RCL	43		
	184	04	04		
	185	=	95		
	186	STO	42		$\frac{2\pi d}{L} = kd \to R_9$
	187	09	09		
	188	2	02	*	
	189	6	06	*	"KD" PRINT CODE
	190	1	01	*	
	191	6	06	*	
	192	OP	69	*	
	193	04	04	*	
	194	RCL	43	*	
	195	09	09	*	
	196	OP	69	*	PRINT Kd
	197	06	06	*	
R/S → SEE BELOW	198	×	65		
	199	2	02		
	200	=	95		
	201	STO	42		
	202	10	10		
	203	SBR	71		
	204	SIN	38		
	205	1/X	35		
	206	×	65		
	207	RCL	43		
	208	10	10		
	209	+	85		
	210	1	01		
	211	=	95		
	212	÷	55		
	213	3	03	*	"N" PRINT CODE
	214	1	01	*	
	215	OP	69	*	

*-DELETE IF PRINTER IS NOT AVAILABLE
R/S-INSERT IF PRINTER IS NOT AVAILABLE

101A-6

STEP	KEY ENTRY	KEY CODE		COMMENTS
216	04	4	*	
217	02	2		
218	95	=		
219	42	STO		$n \rightarrow R_{10}$
220	10	10		
221	69	OP		PRINT n
222	06	06		
223	65	×		
224	01	1	*	
225	05	5	*	"CG" PRINT CODE
226	02	2	*	
227	02	2	*	
228	69	OP	*	
229	04	04	*	
230	43	RCL		
231	04	04		
232	55	÷		
233	43	RCL		
234	02	02		
235	95	=		
236	69	OP	*	PRINT C_g
R/S → 237	06	06	*	
238	35	1/X		
239	65	×		
240	02	2	*	
241	06	6	*	"K_s" PRINT CODE
242	03	3	*	
243	06	6	*	
244	69	OP	*	
245	04	04	*	
246	43	RCL		
247	02	02		
248	65	×		
249	43	RCL		
250	13	13		
251	55	÷		
252	04	4		
253	55	÷		
254	89	π		
255	95	=		
256	34	√X		
257	42	STO		$K_s = \sqrt{C_{g_o}/C_g} \rightarrow R_{10}$
258	10	10		
259	69	OP	*	
260	06	06	*	PRINT K_s
261	02	2	*	
262	06	6	*	"KR" PRINT CODE
263	03	3	*	
264	05	5	*	
265	69	OP	*	
266	04	04	*	
267	43	RCL		
268	00	00		
269	65	×		
270	43	RCL		
271	11	11		
272	55	÷		
273	43	RCL		
274	03	03		
275	55	÷		
276	43	RCL		
277	09	09		
278	95	=		
279	33	X²		
280	75	-		
281	01	1		
282	95	=		
283	94	+/-		
284	35	1/X		$\cos^2\alpha$
285	65	×		
286	53	(		
287	01	1		
288	75	-		
289	43	RCL		
290	00	00		
291	33	X²		
292	95	=		
293	34	√X		
294	34	√X		
● 295	42	STO		
● 296	01	01		
297	69	OP	*	PRINT K_r
298	06	06	*	
299	98	ADV		
300	91	R/S		
301	76	LBL		REMAINING STEPS
302	16	A'		REQUIRED IF CRITICAL
303	42	STO		VELOCITIES ARE
304	08	08		DESIRED
305	02	2	*	$H_o \rightarrow R_8$
306	03	3	*	"HO" PRINT CODE
● 307	00	0	*	
● 308	01	1	*	
309	69	OP	*	
310	04	04	*	
311	43	RCL	*	
312	08	08	*	
● 313	65	×		
314	69	OP	*	PRINT H_o
315	06	06	*	
● 316	43	RCL		
● 317	10	10		
● 318	65	×		
● 319	43	RCL		
● 320	01	01		
● 321	95	=		$H = H_o K_r K_s$
● 322	42	STO		$\rightarrow R_3$
● 323	03	03		
324	65	×		
325	43	RCL		

* - DELETE IF PRINTER IS NOT AVAILABLE
R/S - INSERT IF PRINTER IS NOT AVAILABLE
● - DELETE IF H_1 NOT H_o IS KNOWN

101A-7

STEP	KEY ENTRY	KEY CODE		COMMENTS
326	13	13		
327	65	×		
328	43	RCL		
329	02	02		
330	55	÷		
331	02	2		
332	55	÷		
333	43	RCL		
334	04	04		
335	55	÷		
336	43	RCL		
337	06	06		
338	95	=		$\frac{H}{2}\,\frac{gt}{L}\,\frac{1}{\cosh(\frac{2\pi d}{L})}$
339	42	STO		
340	08	08		$\to R_8$
341	91	R/S		
342	76	LBL		
343	17	B'		
344	42	STO	*	$z \to R_{16}$
345	16	16	*	
346	04	4	*	
347	06	6	*	"z" PRINT CODE
348	69	OP	*	
349	04	04	*	
350	43	RCL	*	
351	16	16	*	
352	69	OP	*	
353	06	06	*	
354	65	×		
355	02	2		
356	65	×		
357	89	π		
358	95	=		
359	42	STO		$2\pi z \to R_{16}$
360	16	16		
361	91	R/S		
362	76	LBL		
363	18	C'		
364	42	STO		$\theta \to R_{15}$
365	15	15		
366	03	3	*	
367	03	3	*	"PANG" PRINT CODE
368	01	1	*	(PHASE ANGLE)
369	03	3	*	
370	03	3	*	
371	01	1	*	
372	02	2	*	
373	02	2	*	
374	69	OP	*	
375	04	04	*	
376	43	RCL	*	
377	15	15	*	
378	69	OP	*	PRINT θ
379	06	06	*	
• 380	02	2	*	

STEP	KEY ENTRY	KEY CODE		COMMENTS
• 381	03	3	*	
• 382	69	OP	*	"H" PRINT CODE
• 383	04	04	*	
• 384	43	RCL		
• 385	03	03		
• 386	69	OP	*	PRINT H
• 387	06	06	*	
• R/S → 388	43	RCL		
389	16	16		
390	85	+		
391	43	RCL		
392	11	11		
393	95	=		
394	55	÷		
395	43	RCL		
396	04	04		
397	95	=		
398	42	STO		$\frac{2\pi(z+d)}{L} \to R_{14}$
399	14	14		
400	71	SBR		
401	39	COS		$\cosh(R_{14})$
402	65	×		
403	04	4	*	
404	01	1	*	"U" PRINT CODE
405	69	OP	*	
406	04	04	*	
407	43	RCL		
408	08	08		
409	65	×		
410	43	RCL		
411	15	15		
412	39	COS		cos θ
413	95	=		
414	69	OP	*	PRINT U
415	06	06	*	
R/S → 416	04	4	*	
417	03	3	*	"W" PRINT CODE
418	69	OP	*	
419	04	04	*	
420	43	RCL		
421	14	14		
422	71	SBR		$\sinh(R_{14})$
423	38	SIN		
424	65	×		
425	43	RCL		
426	08	08		
427	65	×		
428	43	RCL		
429	15	15		
430	38	SIN		sin θ
431	95	=		
432	69	OP	*	
433	06	06	*	PRINT W
434	98	ADV	*	
435	91	R/S		

* – DELETE IF PRINTER IS UNAVAILABLE
R/S – INSERT IF PRINTER IS UNAVAILABLE
• – DELETE IF H, NOT H_0 IS KNOWN

101A-8

Program Description

Program Title	102R Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle (RPN logic)		
Name	T.L. Walton, Jr.	Date	10/80
Address	Coastal Engineering Research Center Kingman Building		
City	Fort Belvoir,	State Virginia	Zip Code 22060

Program Description, Equations, Variables, etc.

This program calculates breaking wave height, H_b, and breaking wave angle, α_b, using linear wave theory approximations combined with the shallow-water breaking assumption. Input parameters are wave height, H, wave period, T, wave angle, α, and the water depth, d, where the preceding three variables are measured. An additional input parameter is nearshore beach slope, m. The ratio of the breaking wave height to the water depth at breaking is predicted using the equation

$$\kappa = H_b/d_b = 1.16\left(\frac{m}{\sqrt{H_o'/L_o}}\right)^{0.22}$$

from Singamsetti and Wind (1980), where d_b is the water depth at breaking, H_o' the deepwater wave height, and L_o the deepwater wavelength. This solution requires the assumption of straight and parallel offshore bottom contours for the application of Snell's law of refraction. Input wave parameters H, T, and α can be in any depth of water, d. Algorithm uses English or metric system of units. The development of the equation is derived on the attached solution sheet.

REFERENCES

SINGAMSETTI, S.R., and WIND, H.G., "Characteristics of Shoaling and Breaking Periodic Waves Normally Incident to Plane Beaches of Constant Slope," Report No. M1371, Toegepast Onberzoek Waterstaat, July 1980.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

102R-1

SOLUTION SHEET FOR PROGRAM 102R

Development of the equation:

From conservations of energy

$$\frac{\gamma H^2}{8} C_g \cos \alpha = \frac{\gamma H_i{}^2}{8} C_{gi} \cos \alpha_i \tag{1}$$

where the subscript i indicates incident wave parameters.

If left hand side of above equation represents conditions at breaking then

$$C_g = C = C_b = \sqrt{g d_b} = \sqrt{g H_b/\kappa} \tag{2}$$

where

$$\kappa = \frac{H_b}{d_b} \tag{3}$$

Now assume

$$\kappa = 1.16 \left(\frac{m}{\sqrt{H_o'/L_o}}\right)^{0.22} \tag{4}$$

where H_o' is unrefracted deepwater wave height.

Using (1), (2), (3), and (4) it can be found

$$H_b = \left\{\left(\frac{\kappa}{g}\right)^{1/2} H_i{}^2 C_{gi} \cos \alpha_i\right\}^{2/5} \tag{5}$$

From Snell's law of refraction

$$\frac{\sin \alpha_b}{C_b} = \frac{\sin \alpha_i}{C_i}$$

therefore,

$$\sin \alpha_b = \left(\frac{\sin \alpha_i}{C_i}\right)\left\{\left(\frac{g}{\kappa} H_b\right)^{1/2}\right\} \tag{7}$$

102R-2

User Instructions

Program Title: 102R Linear Approximation to Breaking Wave Height and Breaking Wave Angle

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	ENTER BOTTOM SLOPE m (TANGENT)	m	A		m
2	ENTER DEPTH d (FEET OR METERS)	d (FT OR M)	B		$2\pi d$
3	ENTER WAVE ANGLE α (DEGREES) AT				
	DEPTH d		C		α
4	ENTER WAVE HEIGHT H (FT OR M) AT				
	DEPTH d		D		H
5	ENTER WAVE PERIOD T (SECONDS)	T(SEC)			
	AND PRESS E FOR ENGLISH UNITS		E		
	OR PRESS f e FOR METRIC UNITS		f	e	
6	READ kd IN DISPLAY				Kd
7	PRESS R/S AND READ n		R/S		n
8	PRESS R/S AND READ C_g (FT OR M)		R/S		C_g
9	PRESS R/S AND READ K_s		R/S		K_s
10	PRESS R/S AND READ H'_o (FT OR M)		R/S		H'_o
11	PRESS R/S AND READ H_b (FT OR M)		R/S		H_b
12	PRESS R/S AND READ α_b (DEGREES)		R/S		α_b
	EXAMPLE:				
	$T = 8$ SEC, $H = 18$ FT, $\alpha = 30°$, $d = 50$ FT,				
	$m = 0.10$				
	ENTER $m = 0.10$, PRESS A	0.10	A		0.10
	ENTER $d = 50$ FT, PRESS B	50	B		50.00
	ENTER $\alpha = 30°$, PRESS C	30	C		30.00
	ENTER $H = 18$ FT, PRESS D	18	D		18.00
	ENTER $T = 8$ SEC, PRESS E	8	E		
	READ kd IN DISPLAY				1.16
	PRESS R/S AND READ $n = 0.73$		R/S		0.73
	PRESS R/S AND READ $C_g = 24.62$ F/S		R/S		24.62
	PRESS R/S AND READ $K_s = 0.91$		R/S		0.91
	PRESS R/S AND READ $H'_o = 19.73$ FT		R/S		19.73
	PRESS R/S AND READ $H_b = 16.98$ FT		R/S		16.98
	PRESS R/S AND READ $\alpha_b = 20.79$		R/S		20.79

102R-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	
	STO E	33 15	$m \rightarrow R_E$
	R/S	84	
	f LBL B	31 25 12	
	STO 1	33 01	$d \rightarrow R_1$
	h π	35 73	
	x	71	
	2	02	
	x	71	
010	STO B	33 12	$2\pi d \rightarrow R_B$
	R/S	84	
	f LBL C	31 25 13	
	STO 0	33 00	$\alpha \rightarrow R_0$
	R/S	84	
	f LBL D	31 25 14	
	STO 8	33 08	$H \rightarrow R_8$
	R/S	84	
	g LBL f e	32 25 15	
	STO 2	33 02	$T \rightarrow R_2$
020	9	09	
	•	83	
	8	08	
	1	01	
	STO D	33 14	g(METRIC) $\rightarrow R_D$
	GTO f b	22 31 12	
	f LBL E	32 25 15	
	STO 2	33 02	$T \rightarrow R_2$
	3	23	
	2	02	
030	.	83	
	2	02	
	STO D	33 14	g(ENGLISH) $\rightarrow R_D$
	g LBL f b	32 25 12	
	RCL 2	34 02	
	g x^2	32 54	
	RCL D	34 14	
	x	71	
	2	02	
	÷	81	
040	h π	35 73	
	÷	81	
	STO 3	33 03	$L_o = \frac{gT^2}{2\pi} \rightarrow R_3$
	g LBL f d	32 25 14	
	STO A	33 11	$L_{OLD} \rightarrow R_A$
	h y^x	35 62	
	RCL B	34 12	
	x	71	
	STO C	33 13	$\frac{2\pi d}{L_{old}} \rightarrow R_C$
	f GSB 2	31 22 02	
050	STO 6	33 06	$\cosh(R_C) \rightarrow R_6$
	RCL C	34 13	
	f GSB 1	31 22 01	
	STO 5	33 05	$\sinh(R_C) \rightarrow R_5$
	RCL 6	34 06	
	÷	81	
	RCL 3	34 03	
	x	71	
	RCL A	34 11	
	+	61	
060	2	02	
	÷	81	
	STO 4	33 04	$L_{NEW} \rightarrow R_4$
	RCL A	34 11	
	−	51	
	h ABS	35 64	
	1	01	
	g x>y	32 81	
	GTO f c	22 31 13	
	RCL 4	34 04	
070	GTO f d	22 31 14	
	g LBL f c	32 25 13	
	RCL B	34 12	
	RCL 4	34 04	
	÷	81	
	STO 9	33 09	$kd \rightarrow R_9$
	R/S	84	Kd IN DISPLAY
	2	02	
	x	71	
	STO A	33 11	$\frac{4\pi d}{L} \rightarrow R_A$
080	f GSB 1	31 22 01	
	h y^x	35 62	
	RCL A	33 11	
	x	71	
	1	01	
	+	61	
	2	02	
	÷	81	
	STO 1	33 01	$n \rightarrow R_1$
	R/S	84	n IN DISPLAY
090	RCL 4	34 64	
	x	71	
	RCL 2	34 02	
	÷	81	
	STO 4	33 04	$C_g \rightarrow R_4$
	R/S	84	C_g IN DISPLAY
	h y^x	35 62	
	RCL 2	34 02	
	x	71	
	RCL D	34 14	
100	x	71	
	4	04	
	÷	81	
	h π	35 73	
	÷	81	
	f $\sqrt{x}$	31 54	
	STO A	33 11	$K_s = \sqrt{\frac{C_{go}}{C_g}} \rightarrow R_A$
	R/S	84	K_s IN DISPLAY
	RCL 8	34 08	
	RCL A	34 11	
110	÷	81	$H'_o = H/K_s$
	R/S	84	H'_o IN DISPLAY
	RCL 3	34 03	

102R-4

STEP	KEY ENTRY	KEY CODE	COMMENTS
	÷	81	
	f √x	31 54	
	RCL E	34 15	
	÷	81	
	h 1/x	35 62	
	.	83	
	2	02	
120	2	02	
	h y^x	35 63	
	1	01	
	.	83	
	1	01	
	6	06	
	×	71	
	RCL D	34 14	
	÷	81	
	STO 6	33 06	$\frac{K}{g} = \frac{1.16}{g}\left(\frac{m}{\sqrt{H_0'/L_0}}\right)^{0.22} \rightarrow R_6$
130	RCL B	34 08	
	g x^2	32 54	
	RCL 4	34 04	
	×	71	
	RCL 0	34 00	
	f cos	31 63	
	×	71	
	.	83	
	4	04	
	h y^x	35 63	
140	RCL 6	34 06	
	.	83	
	2	02	
	h y^x	35 63	
	×	71	
	R/S	84	$\left(\frac{K}{g}\right)^{1/5}\left(H^2 C_g \cos\alpha\right)^{2/5} = H_b$ IN DISPLAY
	RCL 6	34 06	
	h 1/x	35 62	
	×	71	
	f √x	31 54	
150	RCL 0	34 00	
	f SIN	31 62	
	×	71	
	RCL 4	34 04	
	÷	81	$\frac{\sin\alpha}{C}\left(\frac{g}{K} H_b\right)^{1/2} = \sin\alpha_b$
	RCL 1	34 01	
	×	71	
	g $\sin^{-1}$	32 62	
	R/S	84	α_b IN DISPLAY
	f LBL 1	31 25 01	
160	STO 7	33 07	SUBROUTINE SINh ( )
	g e^x	32 52	
	RCL 7	34 07	
	CHS	42	
	g e^x	32 52	
	−	51	
	2	02	
	÷	81	
	h RTN	35 22	
	f LBL 2	31 25 02	SUBROUTINE COSh ( )
170	STO 7	33 07	
	g e^x	32 52	
	RCL 7	34 07	
	CHS	42	
	g e^x	32 52	
	+	61	
	2	02	
	÷	81	
	h RTN	35 22	
180			
190			
200			
210			
220			

102R-5

Program Description

Program Title	102A Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle (AOS logic)		
Name	W.A. Birkemeier	**Date**	5/81
Address	CERC Field Research Facility		
City	Kitty Hawk,	**State** North Carolina	**Zip Code** 27949

Program Description, Equations, Variables, etc.

This program calculates breaking wave height, H_b, and breaking wave angle, α_b, using linear wave theory approximations combined with the shallow-water breaking assumption. Input parameters are wave height, H, wave period, T, wave angle, α, and the water depth, d, where the preceding three variables are measured. An additional input parameter is nearshore beach slope, m. The ratio of the breaking wave height to the water depth at breaking is predicted using the equation

$$\kappa = H_b/d_b = 1.16\left(\frac{m}{\sqrt{H_o'/L_o}}\right)^{0.22}$$

from Singamsetti and Wind (1980), where d_b is the water depth at breaking, H_o' the deepwater wave height, and L_o the deepwater wavelength. This solution requires the assumption of straight and parallel offshore bottom contours for the application of Snell's law of refraction. Input wave parameters H, T, and α can be in any depth of water, d. Algorithm uses English or metric system of units. The development of the equation is derived on the solution sheet included with program 102R.

REFERENCES

SINGAMSETTI, S.R., and WIND, H.G., "Characteristics of Shoaling and Breaking Periodic Waves Normally Incident to Plane Beaches on Constant Slope," Report No. M1371, Toegepast Onberzoek Waterstaat, July 1980.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. I, Ch. 2, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

User Instructions

Program Title: 102A Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	ENTER BOTTOM SLOPE m (TANGENT)	m	A		M
2	ENTER DEPTH d (ft OR M)	d (ft OR M)	B		2nd
3	ENTER WAVE ANGLE AT DEPTH d, α (DEGREES)	α	C		α
4	ENTER WAVE HEIGHT AT DEPTH d H (ft OR M)	H (ft OR M)	D		H
5	ENTER WAVE PERIOD T (SEC)				
	PRESS E FOR ENGLISH UNITS	T (SEC)	E		
	PRESS E' FOR METRIC UNITS		E'		
	NOTE: WITH PRINTER THE FO OWING WAVE				
	PARAMETERS ARE PRINTED AND LABELED				
	$Kd, n, C_g, K_s, H_o', H_b, \alpha_b$				
	WITHOUT PRINTER:				
6	READ Kd IN DISPLAY				Kd
7	PRESS R/S AND READ n		R/S		n
8	PRESS R/S AND READ C_g (ft/SEC OR M/SEC)		R/S		C_g
9	PRESS R/S AND READ K_s		R/S		K_s
10	PRESS R/S AND READ H_o' (ft OR M)		R/S		H_o'
11	PRESS R/S AND READ H_b (ft OR M)		R/S		H_b
12	PRESS R/S AND READ α_b		R/S		α_b
	TO REPEAT ENTER ANY INPUT VARIABLE m, d, α, H				
	AND T. WAVE PERIOD MUST BE ENTERED OR				
	RE-ENTERED.				
	EXAMPLE: CALCULATE WAVE PARAMETERS AND				
	BREAKING WAVE HEIGHT AND DIRECTION FOR:				
	$T = 8$ SEC				
	$H = 18$ ft				
	$\alpha = 30°$				
	$d = 50$ ft				
	$m = 0.1$				

102A-2

User Instructions

Program Title: 102A Linear Wave Approximation to Breaking Wave Height and Breaking Wave Angle

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
	ENTER $m = 0.1$ PRESS A	0.1	A		0.1
	ENTER $d = 50$ ft PRESS B	50 ft	B		314.16
	ENTER $\alpha = 30°$ PRESS C	30°	C		30°
	ENTER $H = 18$ ft PRESS D	18 ft	D		18
	ENTER $T = 8$ SEC PRESS E	8 SEC	E		
	WITH PRINTER $Kd, n, Cg, Ks, H_0', Hb,$				
	AND α_b ARE PRINTED AND LABELED,				
	OTHERWISE:				
	READ Kd IN DISPLAY				1.163
	PRESS R/S READ $n = 0.729$		R/S		0.729
	PRESS R/S READ $Cg = 24.624$ (ft/sec)		R/S		24.625
	PRESS R/S READ $K_s = 0.912$		R/S		0.912
	PRESS R/S READ $H_0' = 19.728$ (ft)		R/S		19.728
	PRESS R/S READ $Hb = 16.981$ (ft)		R/S		16.981
	PRESS R/S READ $\alpha_b = 20.786°$		R/S		20.786°
	PRINTED OUTPUT OF EXAMPLE				
	0.1 M				
	50. D				
	30. ANG				
	18. H				
	8. T				
	1.16314388 KD				
	0.729367164 N				
	24.62479667 CG				
	.9123924245 KS				
	19.72835319 HO'				
	16.98073853 HB				
	20.78594881 ANGB				

102A-3

Program Listing

STEP	KEY ENTRY	KEY CODE		COMMENTS
000	76	LBL		
001	11	A		
002	42	STO		M → R_{14}
003	14	14		
004	03	3	*	"M" PRINT CODE
005	00	0	*	
006	69	OP	*	
007	04	04	*	
008	43	RCL	*	
009	14	14	*	
010	69	OP	*	
011	06	06	*	PRINT M
012	91	R/S		
013	76	LBL		
014	12	B		
015	42	STO		d → R_1
016	01	01		
017	01	1	*	"D" PRINT CODE
018	06	6	*	
019	69	OP	*	
020	04	04	*	
021	43	RCL	*	
022	01	01	*	
023	69	OP	*	PRINT d
024	06	06	*	
025	65	×		
026	89	π		
027	65	×		
028	02	2		
029	95	=		
030	42	STO		$2\pi d$ → R_{11}
031	11	11		
032	91	R/S		
033	76	LBL		
034	13	C		
035	42	STO		α → R_0
036	00	00		
037	01	1	*	
038	03	3	*	"ANG" PRINT CODE
039	03	3	*	
040	01	1	*	
041	02	2	*	
042	02	2	*	
043	69	OP	*	
044	04	04	*	
045	43	RCL	*	
046	00	00	*	
047	69	OP	*	
048	06	06	*	
049	91	R/S		
050	76	LBL		
051	14	D		
052	42	STO		H → R_8
053	08	08		
054	02	2	*	"H" PRINT CODE
055	03	3	*	
056	69	OP	*	
057	04	04	*	
058	43	RCL	*	
059	08	08	*	
060	69	OP	*	
061	06	06	*	PRINT H
062	91	R/S		
063	76	LBL		SUBROUTINE TO
064	38	SIN		COMPUTE
065	42	STO		
066	07	07		sin h (x)
067	22	INV		
068	23	LNX		
069	75	-		
070	43	RCL		
071	07	07		
072	94	+/-		
073	22	INV		
074	23	LNX		
075	95	=		
076	55	÷		
077	02	2		
078	95	=		
079	92	RTN		
080	76	LBL		SUBROUTINE TO
081	39	COS		COMPUTE
082	42	STO		cos h (x)
083	07	07		
084	22	INV		
085	23	LNX		
086	85	+		
087	43	RCL		
088	07	07		
089	94	+/-		
090	22	INV		
091	23	LNX		
092	95	=		
093	55	÷		
094	02	2		
095	95	=		
096	92	RTN		
097	76	LBL		E' ALLOWS METRIC
098	10	E'		DATA ENTRY
099	42	STO		
100	02	02		T → R_2
101	09	9		
102	93	.		g = 9.81
103	08	8		
104	01	1		
105	42	STO		g → R_{13}
106	13	13		
107	03	3	*	

102A-4

* - DELETE IF PRINTER IS NOT AVAILABLE

STEP	KEY CODE	KEY ENTRY		COMMENTS
108	00	0	*	"M" PRINT CODE
109	69	OP	*	
110	04	04	*	
111	69	OP	*	
112	05	05	*	
113	17	B'		
114	76	LBL		
115	15	E		"E" ALLOWS
116	42	STO		ENGLISH UNITS
117	02	02		$T \rightarrow R_2$
118	03	3		$g = 32.2$ ft/sec²
119	02	2		
120	93	.		
121	02	2		
122	42	STO		
123	13	13		$\rightarrow R_{13}$
124	76	LBL		
125	17	B'		
126	01	1		1 → t REGISTER
127	32	X⇌T		
128	03	3	*	"T" PRINT CODE
129	07	7	*	
130	69	OP	*	
131	04	04	*	
132	43	RCL		
133	02	02		
134	69	OP	*	PRINT T
135	06	06	*	
136	33	X²		
137	65	×		
138	43	RCL		
139	13	13		
140	55	÷		
141	02	2		
142	55	÷		
143	89	π		
144	95	=		$L_0 = gT^2/2\pi$
145	42	STO		
146	03	03		$\rightarrow R_3$
147	76	LBL		
148	19	D'		
149	42	STO		
150	10	10		$L_{OLD} \rightarrow R_{10}$
151	35	1/X		
152	65	×		
153	43	RCL		
154	11	11		
155	95	=		
156	42	STO		$\frac{2\pi d}{L_{OLD}} \rightarrow R_{12}$
157	12	12		
158	71	SBR		
159	39	COS		$\cosh\left(\frac{2\pi d}{L_{OLD}}\right) \rightarrow R_6$
160	42	STO		
161	06	06		

STEP	KEY CODE	KEY ENTRY		COMMENTS
162	43	RCL		
163	12	12		
164	71	SBR		
165	38	SIN		$\sinh\left(\frac{2\pi d}{L_{OLD}}\right) \rightarrow R_5$
166	42	STO		
167	05	05		
168	55	÷		
169	43	RCL		
170	06	06		
171	65	×		
172	43	RCL		
173	03	03		
174	85	+		
175	43	RCL		
176	10	10		
177	95	=		
178	55	÷		
179	02	2		
180	95	=		
181	42	STO		$L_{NEW} \rightarrow R_4$
182	04	04		
183	75	-		
184	43	RCL		
185	10	10		
186	95	=		
187	50	I×I		ITERATE UNTIL
188	22	INV		$L_{NEW} - L_{OLD} < t$
189	77	GE		WHERE t IS VALUE
190	18	C'		IN t register
191	43	RCL		
192	04	04		
193	19	D'		
194	76	LBL		
195	18	C'		
196	43	RCL		
197	11	11		
198	55	÷		
199	02	2	*	
200	06	6	*	"KD" PRINT CODE
201	01	1	*	
202	06	6	*	
203	69	OP	*	
204	04	04	*	
205	43	RCL		
206	04	04		
207	95	=		
208	42	STO		$\frac{2\pi d}{L} = Kd \rightarrow R_9$
209	09	09		
210	69	OP	*	
211	06	06	*	PRINT Kd
R/S SEE BELOW → 212	65	×		
213	02	2		
214	95	=		
215	42	STO		

102A-5

* - DELETE IF PRINTER IS UNAVAILABLE
R/S - INSERT IF PRINTER IS UNAVAILABLE

	STEP	KEY ENTRY	KEY CODE		COMMENTS
	216	10	E'		$\frac{4\pi d}{L} \to R_{10}$
	217	71	SBR		
	218	38	SIN		
	219	35	1/X		
	220	65	×		
	221	43	RCL		
	222	10	10		
	223	85	+		
	224	01	1		
	225	95	=		
	226	55	÷		
	227	03	3	*	
	228	01	1	*	"N" PRINT CODE
	229	69	OP	*	
	230	04	04	*	
	231	02	2		
	232	95	=		
	233	42	STO		
	234	01	01		$n \to R_1$
	235	69	OP	*	
	236	06	06	*	PRINT n
	237	65	×		
	238	01	1	*	
	239	05	5	*	
	240	02	2	*	"CG" PRINT CODE
	241	02	2	*	
	242	69	OP	*	
	243	04	04	*	
	244	43	RCL		
	245	04	04		
	246	55	÷		
	247	43	RCL		
	248	02	02		
	249	95	=		
	250	42	STO		
	251	04	04		$CG \to R_4$
	252	69	OP	*	
	253	06	06	*	PRINT Cg
	254	35	1/X		
	255	65	×		
	256	02	2	*	
	257	06	6	*	
	258	03	3	*	"KS" PRINT CODE
	259	06	6	*	
	260	69	OP	*	
	261	04	04	*	
	262	43	RCL		
	263	02	02		
	264	65	×		
	265	43	RCL		
	266	13	13		
	267	55	÷		
	268	04	4		
	269	55	÷		
	270	89	π		
	271	95	=		
	272	34	√X		
	273	42	STO		
	274	10	10		$K_s = \sqrt{\frac{Cg_0}{Cg}} \to R_{10}$
	275	69	OP	*	
	276	06	06	*	PRINT K_s
R/S SEE BELOW →	277	02	2	*	STEPS 277 TO 379
	278	03	3	*	COMPUTE H_s AND α_b
	279	00	0	*	
	280	01	1	*	"H0'" PRINT CODE
	281	06	6	*	
	282	05	5	*	
	283	69	OP	*	
	284	04	04	*	
	285	43	RCL		
	286	08	08		
	287	55	÷		
	288	43	RCL		$H_0' = \frac{H}{K_s}$
	289	10	10		
	290	95	=		
	291	69	OP	*	PRINT H_0'
	292	06	06	*	
R/S SEE BELOW →	293	55	÷		
	294	43	RCL		
	295	03	03		
	296	95	=		
	297	34	√X		
	298	55	÷		
	299	43	RCL		
	300	14	14		
	301	95	=		
	302	35	1/X		
	303	45	Y^x		
	304	93	.		
	305	02	2		
	306	02	2		
	307	65	×		
	308	01	1		
	309	93	.		
	310	01	1		
	311	06	6		
	312	55	÷		
	313	43	RCL		
	314	13	13		
	315	95	=		
	316	42	STO		$\frac{K}{g} = \frac{1.16}{g}\left(\frac{m/\sqrt{H_0}}{L_0}\right)^{.22}$
	317	06	06		
	318	43	RCL		
	319	08	08		$\to R_6$
	320	33	X^2		
	321	65	×		
	322	43	RCL		
	323	04	04		

102A-6

* - DELETE IF PRINTER IS UNAVAILABLE
R/S - INSERT IF PRINTER IS UNAVAILABLE

STEP	KEY ENTRY	KEY CODE	COMMENTS
324	65	×	
325	43	RCL	
326	00	00	
327	39	COS	
328	95	=	
329	45	Y^{x}	
330	93	.	
331	04	4	$(H^2 C_g \cos\alpha)^{2/5}$
332	65	×	
333	02	2 *	
334	03	3 *	
335	01	1 *	
336	04	4 *	'HB' PRINT CODE
337	69	OP *	
338	04	04 *	
339	43	RCL	
340	06	06	
341	45	Y^{x}	
342	93	.	
343	02	2	$\left(\frac{k}{g}\right)^{-2}(H^2 C_g \cos\alpha)^{2/5}$
344	95	=	
345	69	OP *	PRINT H_b
346	06	06 *	
R/S SEE BELOW → 347	65	×	
348	43	RCL	
349	06	06	
350	35	1/X	
351	95	=	
352	34	√X	
353	65	×	
354	43	RCL	
355	00	00	
356	38	SIN	
357	55	÷	
358	01	1 *	
359	03	3 *	
360	03	3 *	
361	01	1 *	"ANGB" PRINT CODE
362	02	2 *	
363	02	2 *	
364	01	1 *	
365	04	4 *	
366	69	OP *	
367	04	04 *	
368	43	RCL	
369	04	04	
370	65	×	
371	43	RCL	
372	01	01	
373	95	=	$\sin\alpha_b = \frac{\sin\alpha}{C_i}\left(\frac{g}{k}H_b\right)^{1/2}$
374	22	INV	
375	38	SIN	
376	69	OP *	PRINT α_b
377	06	06 *	

STEP	KEY ENTRY	KEY CODE	COMMENTS
378	98	ADV	
379	91	R/S	

102A-7

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Program Description

Program Title	103R Shallow-Water Wave Forecasting Equations (RPN logic)
Name	T.L. Walton, Jr. — **Date** 10/80
Address	Coastal Engineering Research Center
City	Kingman Building Fort Belvoir, — **State** Virginia — **Zip Code** 22060

Program Description, Equations, Variables, etc.

This algorithm computes the wave height, H, wave period, T, and minimum duration, t, from input values of the water depth, d, fetch length, F, and adjusted windspeed, U_A, using equations (1), (2), and (3) of CETN-I-6. Equations (1) and (2) are for constant water depth and unlimited wind duration and have been revised from equations (3-25) and (3-26) of the Shore Protection Manual. Wave height and period in this algorithm are significant wave height and period. Algorithm uses English or metric system of units.

REFERENCES

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I, II, and III, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, 1,262 pp.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Method for Determining Adjusted Windspeed, U_A, for Wave Forecasting," CETN-I-5, Fort Belvoir, Va., 1981.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Shallow Water," CETN-I-6, Fort Belvoir, Va., 1981.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Deep Water," CETN-I-7, Fort Belvoir, Va., 1981.

Operating Limits and Warnings

User Instructions

Program Title: 103R Shallow Water Wave Forecasting Equations

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	ENTER ADJUSTED WIND SPEED	UA(MPH)			
	UA IN EITHER MPH OR KPH	UA(KPH)	A		UA
2	ENTER FETCH LENGTH F IN	F (MI)			
	EITHER MILES OR KILOMETERS	F (KM)	B		F
3	ENTER DEPTH d IN FEET				
	OR IN METERS		C		d
4	TO COMPUTE H,T IN ENGLISH UNITS				
	PRESS E, READ H		E		H (FT)
5	PRESS R/S, READ T		R/S		T (SEC)
6	PRESS R/S, READ t		R/S		t (HOURS)
	OR				
4a	TO COMPUTE H,T IN METRIC UNITS				
	PRESS f e, READ H (M)		f	e	H (M)
	PRESS R/S, READ T (SEC)		R/S		T (SEC)
	EXAMPLE				
	UA = 40 MPH ; F = 300 M ; d = 20 FT				
	ENTER UA = 40 MPH, PRESS A	40	A		40.00
	ENTER F = 300 M, PRESS B	300	B		300.00
	ENTER d = 20 FT, P	20	C		20.00
	PRESS E, READ H = 4.53 FT		E		4.53 (FT)
	PRESS R/S, READ T = 5.60 SEC		R/S		5.60 (SEC)
	PRESS R/S, READ t = 3.73 HRS		R/S		3.73 (HRS)

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Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	
	STO 3	33 03	$U_A \rightarrow R_3$
	R/S	84	
	f LBL B	31 25 12	
	STO 5	33 05	$F \rightarrow R_5$
	R/S	84	
	f LBL C	31 25 13	
	STO 6	33 06	$d \rightarrow R_6$
	R/S	84	
010	f LBL E	31 25 15	
	3	03	
	2	02	
	.	83	
	2	02	
	STO 9	33 09	g(ENGLISH) $\rightarrow R_9$
	1	01	
	.	83	
	4	04	
	7	07	
020	STO 7	33 07	CONVERSION FACTOR $\rightarrow R_7$
	5	05	
	2	02	
	8	08	
	0	00	
	STO 1	33 01	CONVERSION FACTOR $\rightarrow R_1$
	GTO f d	22 31 14	
	g LBL f e	32 25 15	
	9	09	
	.	83	
030	8	08	
	1	01	
	STO 9	33 09	g(METRIC) $\rightarrow R_9$
	.	83	
	2	02	
	7	07	
	7	07	
	8	08	
	STO 7	33 07	CONVERSION FACTOR $\rightarrow R_7$
	1	01	
040	0	00	
	0	00	
	0	00	
	STO 1	33 01	CONVERSION FACTOR $\rightarrow R_1$
	g LBL f d	32 25 14	
	RCL 3	34 03	
	RCL 7	34 07	
	x	71	
	STO 7	33 07	$U_A \rightarrow R_7$ CONVERTED
	RCL 9	34 09	
050	RCL 7	34 07	
	g x^2	32 52	
	÷	81	
	STO 8	33 08	$g/U_A^2 \rightarrow R_8$
	RCL 6	34 06	
	x	71	
	STO 0	33 00	$gd/U_A^2 \rightarrow R_0$
	RCL 8	34 08	
	RCL 1	34 01	
	x	71	
060	RCL 5	34 05	
	x	71	
	STO 1	33 01	$\frac{gF}{U_A^2} \rightarrow R_1$
	RCL 0	34 00	
	.	83	
	7	07	
	5	05	
	h y^x	35 63	
	.	83	
	5	05	
070	3	03	
	x	71	
	f GSB 1	31 22 01	
	STO 4	33 04	$\tanh\left[.53\left(\frac{gd}{U_A^2}\right)^{.75}\right] \rightarrow R_4$
	RCL 1	34 01	
	f $\sqrt{x}$	31 54	
	.	83	
	0	00	
	0	00	
	5	05	
080	6	06	
	5	05	
	x	71	
	RCL 4	34 04	
	÷	81	
	f GSB 1	31 22 01	$\tanh\left[\frac{.00565}{R_4}\left(\frac{gF}{U_A^2}\right)^{.5}\right]$
	RCL 4	34 04	
	x	71	
	.	83	
	2	02	
090	8	08	
	3	03	
	x	71	
	RCL 8	34 08	
	÷	81	
	R/S	84	H IN DISPLAY
	RCL 0	34 00	
	.	83	
	3	03	
	7	07	
100	5	05	
	h y^x	35 63	
	.	83	
	8	08	
	3	03	
	3	03	
	x	71	
	f GSB 1	31 22 01	
	STO 4	33 04	$\tanh\left[.833\left(\frac{gd}{U_A^2}\right)^{.375}\right] \rightarrow R_4$
	RCL 1	34 01	
110	.	83	
	3	03	
	3	03	

103R-3

STEP	KEY ENTRY	KEY CODE	COMMENTS
	3	03	
	h y^x	35 63	
	.	83	
	0	00	
	3	03	
	7	07	
	9	09	
120	x	71	
	RCL 4	34 04	
	÷	81	
	f GSB 1	31 22 01	$\tanh\left[\frac{.0379\left(\frac{gF}{U_A^2}\right)^{.333}}{R4}\right]$
	RCL 4	34 04	
	x	71	
	7	07	
	.	83	
	5	05	
	4	04	
130	x	71	
	RCL 8	34 08	
	÷	81	
	RCL 7	34 07	
	÷	81	
	R/S	84	T IN DISPLAY
	RCL 9	34 09	
	x	71	
	RCL 7	34 07	
	÷	81	
140	2	02	
	.	83	
	3	03	
	3	03	
	3	03	
	h y^x	35 63	
	5	05	
	3	03	
	7	07	
	x	71	
150	RCL 7	34 07	
	x	71	
	RCL 9	34 09	
	÷	81	t (SECONDS)
	3	03	
	6	06	
	0	00	
	0	00	
	÷	81	
	R/S	84	t (HRS) IN DISPLAY
160	f LBL 1	31 25 01	SUBROUTINE
	STO 2	33 02	tanh ( )
	g e^x	32 52	
	RCL 2	34 02	
	CHS	42	
	g e^x	32 52	
	−	51	
	RCL 2	34 02	
	g e^x	32 52	
	RCL 2	34 02	
170	CHS	42	
	g e^x	32 52	
	+	61	
	÷	81	
	h RTN	35 22	
180			
190			
200			
210			
220			

103R-4

Program Description

Program Title 103A Shallow-Water Wave Forecasting Equations (AOS logic)

Name W.A. Birkemeier **Date** 5/81

Address CERC Field Research Facility

City Kitty Hawk, **State** North Carolina **Zip Code** 27949

Program Description, Equations, Variables, etc.

This algorithm computes the wave height, H, wave period, T, and minimum duration, t, from input values of the water depth, d, fetch length, F, and adjusted windspeed, U_A, using equations (1), (2), and (3) of CETN-I-6. Equations (1) and (2) are for constant water depth and unlimited wind duration and have been revised from equations (3-25) and (3-26) of the Shore Protection Manual. Wave height and period in this algorithm are significant wave height and period. Algorithm uses English or metric system of units.

REFERENCES

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I, II, and III, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, 1,262 pp.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Method for Determining Adjusted Windspeed, U_A, for Wave Forecasting," CETN-I-5, Fort Belvoir, Va., 1981.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Shallow Water," CETN-I-6, Fort Belvoir, Va., 1981.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, "Revised Method for Wave Forecasting in Deep Water," CETN-I-7, Fort Belvoir, Va., 1981.

Operating Limits and Warnings

103A-1

User Instructions

Program Title: 103A Shallow-Water Wave Forecasting Equations

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	ENTER ADJUSTED WIND SPEED				
	(UA) IN EITHER MPH OR KPH	UA	A		UA
2	ENTER FETCH LENGTH (F) IN EITHER				
	MILES OR KILOMETERS	F	B		F
3	ENTER DEPTH (d) IN FEET OR METERS	d	C		d
4	TO COMPUTE H, T, AND t				
	PRESS E FOR ENGLISH UNITS		E		
	PRESS E' FOR METRIC UNITS		2nd	E'	
	WITH PRINTER, H, T, AND t ARE				
	AUTOMATICALLY PRINTED AND LABELED				
	OTHERWISE:				
5	READ H IN DISPLAY (ft or m)				H (ft or m)
6	PRESS R/S AND READ T IN DISPLAY		R/S		T (sec)
7	PRESS R/S AND READ THE MINIMUM				
	DURATION t IN HOURS		R/S		t (hrs)
	EXAMPLE: COMPUTE SIGNIFICANT WAVE				
	HEIGHT AND PERIOD FOR THE FOLLOWING				
	CONDITIONS UA = 40 mph				
	F = 300 m.				
	d = 20 ft.				
	ENTER UA = 40 PRESS A	40 mph	A		40
	ENTER F = 300 PRESS B	300 mi	B		300
	ENTER d = 20 PRESS C	20 ft	C		20
	PRESS E AND READ H = 4.53 ft				4.53 ft
	PRESS R/S AND READ T = 5.60 SEC		R/S		5.60 sec
	PRESS R/S AND READ. t = 3.73 HRS		R/S		3.73 hrs
	PRINTOUT OF EXAMPLE				
	40. UA				
	300. F				
	20. D				
	4.531271188 H				
	5.603173088 T				
	3.726684287 HRS				

103A-2

STEP	KEY ENTRY	KEY CODE		COMMENTS
000	76	LBL		
001	11	A		
002	42	STO		$U_A \rightarrow R_{10}$
003	10	10		
004	04	4	*	
005	01	1	*	"U_A" PRINT CODE
006	01	1	*	
007	03	3	*	
008	69	OP	*	
009	04	04	*	
010	43	RCL	*	
011	10	10	*	
012	69	OP	*	PRINT UA
013	06	06	*	
014	91	R/S		
015	76	LBL		
016	12	B		
017	42	STO		$F \rightarrow R_5$
018	05	05		
019	02	2	*	"F" PRINT CODE
020	01	1	*	
021	69	OP	*	
022	04	04	*	
023	43	RCL	*	
024	05	05	*	
025	69	OP	*	PRINT F
026	06	06	*	
027	91	R/S		
028	76	LBL		
029	13	C		
030	42	STO		$d \rightarrow R_6$
031	06	06		
032	01	1	*	"D" PRINT CODE
033	06	6	*	
034	69	OP	*	
035	04	04	*	
036	43	RCL	*	
037	06	06	*	
038	69	OP	*	PRINT d
039	06	06	*	
040	91	R/S		
041	76	LBL		LBLE - SELECTS
042	15	E		ENGLISH UNITS
043	03	3		
044	02	2		$g = 32.2$ ft/sec^2
045	93	.		
046	02	2		
047	42	STO		$g \rightarrow R_9$
048	09	09		
049	01	1		TO CONVERT UA
050	93	.		TO ft/SEC
051	04	4		(MULTIPLY BY 1.47)
052	07	7		
053	42	STO		$1.47 \rightarrow R_7$

STEP	KEY ENTRY	KEY CODE		COMMENTS
054	07	07		
055	05	5		
056	02	2		TO CONVERT F
057	08	8		TO FEET (MULTIPLY
058	00	0		BY 5280)
059	42	STO		$\rightarrow 01$
060	01	01		
061	19	D'		
062	76	LBL		LBL E SELECTS
063	10	E'		METRIC UNITS
064	09	9		
065	93	.		
066	08	8		$g = 9.81$
067	01	1		
068	42	STO		$\rightarrow R_9$
069	09	09		
070	93	.		CONVERT U_A TO
071	02	2		M/SEC MULTIPLY
072	07	7		Kph BY 0.2778
073	07	7		
074	08	8		
075	42	STO		$\rightarrow R_7$
076	07	07		
077	01	1		CONVERT F TO
078	00	0		METERS MULTIPLY
079	00	0		km. BY 1000
080	00	0		
081	42	STO		$\rightarrow R_{01}$
082	01	01		
083	03	3	*	
084	00	0	*	"M" PRINT CODE
085	69	OP	*	
086	04	04	*	
087	69	OP	*	PRINT "M" TO
088	05	05	*	INDICATE METRIC
089	76	LBL		
090	19	D'		
091	43	RCL		CONVERT U_A
092	10	10		STORE IN R_7
093	49	PRD		
094	07	07		
095	43	RCL		
096	09	09		
097	55	÷		
098	43	RCL		
099	07	07		
100	33	X²		
101	95	=		
102	42	STO		$g/U_A^2 \rightarrow R_8$
103	08	08		
104	49	PRD		
105	01	01		
106	65	×		
107	43	RCL		

103A-3

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
108	06	06		162	=	95	
109	=	95		163	OP	69	* PRINT H
110	STO	42	$dg/U_A^2 \rightarrow R_0$	R/S SEE BELOW → 164	06	06	*
111	00	00		165	3	03	* "T" PRINT CODE
112	RCL	43		166	7	07	*
113	05	05		167	OP	69	*
114	PRD	49	$Fg/U^2 \rightarrow R_1$	168	04	04	*
115	01	01		169	RCL	43	
116	2	02	* "H" PRINT CODE	170	00	00	
117	3	03	*	171	YX	45	
118	OP	69	*	172	.	93	
119	04	04	*	173	3	03	
120	RCL	43		174	7	07	
121	00	00		175	5	05	
122	YX	45		176	×	65	
123	.	93		177	.	93	
124	7	07		178	8	08	
125	5	05		179	3	03	
126	×	65		180	3	03	
127	.	93		181	=	95	
128	5	05		182	SBR	71	$\tanh\left[.833\left(\frac{dg}{U_A^2}\right)^{.375}\right] \rightarrow R_4$
129	3	03		183	TAN	30	
130	=	95		184	STO	42	
131	SBR	71	$\tanh\left[.53\left(\frac{gd}{U_A^2}\right)^{.75}\right] \rightarrow R_4$	185	04	04	
132	TAN	30		186	RCL	43	
133	STO	42		187	01	01	
134	04	04		188	YX	45	
135	RCL	43		189	.	93	
136	01	01		190	3	03	
137	√X	34		191	3	03	
138	×	65		192	3	03	
139	.	93		193	×	65	
140	0	00		194	.	93	
141	0	00		195	0	00	
142	5	05		196	3	03	
143	6	06		197	7	07	
144	5	05		198	9	09	
145	÷	55		199	÷	55	
146	RCL	43		200	RCL	43	
147	04	04		201	04	04	
148	=	95		202	=	95	
149	SBR	71	$\tanh\left[\frac{.00565\left(\frac{Fg}{U_A^2}\right)^{.5}}{R_4}\right]$	203	SBR	71	$\tanh\left[\frac{.0379\left(\frac{Fg}{U_A^2}\right)^{.333}}{R_4}\right]$
150	TAN	30		204	TAN	30	
151	×	65		205	×	65	
152	RCL	43		206	RCL	43	
153	04	04		207	04	04	
154	×	65		208	×	65	
155	.	93		209	7	07	
156	2	02		210	.	93	
157	8	08		211	5	05	
158	3	03		212	4	04	
159	÷	55		213	÷	55	
160	RCL	43		214	RCL	43	
161	08	08		215	08	08	

103A-4

* DELETE IF PRINTER IS UNAVAILABLE
R/S-INSERT IF PRINTER IS UNAVAILABLE

STEP	KEY ENTRY	KEY CODE	COMMENTS
216	55	-	
217	43	RCL	
218	07	07	
219	95	=	
220	69	OP *	PRINT T
R/S → 221	06	06 *	
222	65	×	
223	43	RCL	
224	09	09	
225	55	÷	
226	02	2 *	
227	03	3 *	"HRS" PRINT CODE
228	03	3 *	
229	05	5 *	
230	03	3 *	
231	06	6 *	
232	69	OP *	
233	04	04 *	
234	43	RCL	
235	07	07	
236	95	=	
237	45	Y×	
238	53	(	
239	07	7	
240	55	÷	
241	03	3	
242	54	)	
243	65	×	
244	05	5	
245	03	3	
246	07	7	
247	65	×	
248	43	RCL	
249	07	07	
250	55	÷	
251	43	RCL	$t = \frac{U_A}{g} 537 \left(\frac{T_0}{U_A}\right)^{7/3}$
252	09	09	
253	55	÷	
254	03	3	CONVERT SECONDS TO HOURS
255	06	6	
256	00	0	
257	00	0	
258	95	=	
259	69	OP *	PRINT MINIMUM DURATION t
260	06	06 *	
261	98	ADV *	
262	91	R/S	
263	76	LBL	SUBROUTINE TO COMPUTE TANH(x)
264	30	TAN	
265	42	STO	
266	02	02	
267	22	INV	
268	23	LNX	
269	75	-	
270	48	EXC	
271	02	02	
272	94	+/-	
273	22	INV	
274	23	LNX	
275	42	STO	
276	03	03	
277	95	=	
278	55	÷	
279	53	(	
280	43	RCL	
281	02	02	
282	85	+	
283	43	RCL	
284	03	03	
285	95	=	
286	92	RTN	

103A-5

*- DELETE IF A PRINTER IS UNAVAILABLE

R/S - INSERT IF PRINTER IS UNAVAILABLE

Program Description

Program Title	104R Depth-Limited Design Breaking Wave Height at Structure (RPN logic)		
Name	T.L. Walton, Jr.	Date	10/80
Address	Coastal Engineering Research Center Kingman Building		
City	Fort Belvoir, Virginia	Zip Code	22060

Program Description, Equations, Variables, etc.

This algorithm computes the depth-limited breaking wave height at a structure for design purposes. It can be used in lieu of Figure 7-4 of the Shore Protection Manual. The equation for the curves in Figure 7-4 is not given in the SPM but can be found by simultaneous solution of SPM equations (2-91), (2-92), (2-93), (7-3), and (7-4). Input is wave period, T, and water depth at the structure toe, d_s. The development of the equation is derived on the attached solution sheet. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I and II, Chs, 2 and 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

104R-1

SOLUTION SHEET FOR PROGRAM 104R

The following equations are given in the Shore Protection Manual:

$$\frac{d_b}{H_b} = \frac{1}{b - (aH_b/gT^2)} \tag{2-91}$$

$$a = 43.75(1 - e^{-19m}) \tag{2-92}$$

$$b = \frac{1.56}{(1 + e^{-19.5m})} \tag{2-93}$$

$$x_p = \tau_p H_b = (4.0 - 9.25\ m)H_b \tag{7-3}$$

$$H_b = \frac{d_s}{\beta - m\tau_p} \tag{7-4}$$

Equation (7-4) can be rewritten in dimensionless form as:

$$\hat{H}_b = \frac{\hat{d}_s}{\left[(b - a\hat{H}_b)^{-1} - m\tau_p\right]}$$

where

$$\hat{H}_b = H_b/gT^2 \text{ and } \hat{d}_s = d_s/gT^2$$

The above equation can then be solved via the quadratic formula for $\hat{H}_b$ in terms of $\hat{d}_s$, τ_p, m, a, and b where the positive root provides useful results.

$$\hat{H}_b = \left\{(m\tau_p b - a\hat{d}_s - 1) + \left[(m\tau_p b - a\hat{d}_s - 1)^2 + 4am\tau_p\ b\hat{d}_s\right]^{1/2}\right\}.(2am\tau_p)^{-1}$$

This is the equation used in the program for design breaking wave height.

User Instructions

Program Title: 104R Depth-Limited Design Breaking Wave Height at Structure

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	ENTER BOTTOM SLOPE m (TANGENT)	m	A		m
2	ENTER DEPTH AT STRUCTURE				
	ds (FEET OR METERS)	ds	B		ds
3	ENTER WAVE PERIOD T (SEC)				
	PRESS E FOR ENGLISH UNITS	T(FT)	E		
	PRESS fe FOR METRIC UNITS	T(M)	f	e	
4	READ Hb IN DISPLAY				Hb(FT or M)
5	FOR NEW T GO TO STEP 3				
	NOTE: WITH PRINTER, m, ds, T, Hb				
	ARE PRINTED AND LABELED				
	EXAMPLE:				
	ds = 10 FT, T = 10 SEC, m = 0.10				
	ENTER m = 0.10, PRESS A	0.10	A		0.10
	ENTER ds = 10 FT, PRESS B	10 FT	B		10.00
	ENTER T = 10 SEC, PRESS E	10 SEC	E		
	READ Hb = 17.98 IN DISPLAY				17.98

104R-3

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	
	STO 0	33 00	$m \to R_0$
	R/S	84	
	f LBL B	31 25 12	
	STO 7	33 07	$d_s \to R_7$
	R/S	84	
	g LBL f e	32 25 15	
	STO 9	33 09	$T \to R_9$
	9	09	
010	.	83	
	8	08	
	1	01	
	STO 8	33 08	g (METRIC) $\to R_8$
	GTO f d	22 31 14	
	f LBL E	31 25 15	
	STO 9	33 09	$T \to R_9$
	3	03	
	2	02	
	.	83	
020	2	02	
	STO 8	33 08	g (ENGLISH) $\to R_8$
	g LBL f d	32 25 14	
	RCL 7	34 07	
	RCL 8	34 08	
	÷	81	
	RCL 9	34 09	
	g x^2	32 54	
	÷	81	
	STO 1	33 01	$\frac{d_s}{gT^2} \to R_1$
030	RCL 0	34 00	
	1	01	
	9	09	
	x	71	
	CHS	42	
	g e^x	32 52	
	CHS	42	
	1	01	
	+	61	
	4	04	
040	3	03	
	.	83	
	7	07	
	5	05	
	x	71	
	STO 3	33 03	$43.75(1-e^{-19m}) = a \to R_3$
	RCL 0	34 00	
	1	01	
	9	09	
	.	83	
050	5	05	
	x	71	
	CHS	42	
	g e^x	32 52	
	1	01	
	+	61	
	1	01	
	.	83	
	5	05	
	6	06	
060	÷	81	
	h y^x	35 62	
	STO 4	33 04	
	RCL 0	34 00	
	ENTER	41	
	9	09	
	.	83	
	2	02	
	5	05	
	x	71	
070	4	04	
	−	51	
	CHS	42	
	RCL 0	34 00	
	x	71	
	STO 5	33 05	$m\tau_p = m(4-9.25m) \to R_5$
	RCL 4	34 04	
	x	71	
	1	01	
	−	51	
080	RCL 1	34 01	
	RCL 3	34 03	
	x	71	
	−	51	
	STO 6	33 06	$m\tau_p b - a\hat{d}_s - 1 \to R_6$
	g x^2	32 54	
	4	04	
	RCL 3	34 03	
	x	71	
	RCL 4	34 04	
090	x	71	
	RCL 5	34 05	
	x	71	
	RCL 1	34 01	
	x	71	
	+	61	
	f $\sqrt{x}$	31 54	$((R_6)^2 + 4am\tau_p)^{1/2}$
	RCL 6	34 06	
	+	61	
	2	02	
100	÷	81	
	RCL 3	34 03	
	÷	81	
	RCL 5	34 05	$\hat{H}_b = \frac{H_b}{gT^2}$
	÷	81	
	RCL 1	34 01	
	÷	81	
	RCL 7	34 07	
	x	71	
	R/S	84	H_b IN DISPLAY
110			

104R-4

Program Description

Program Title	104A Depth-Limited Design Breaking Wave Height at Structure (AOS logic)		
Name	W.A. Birkemeier	Date	5/81
Address	CERC Field Research Facility		
City	Kitty Hawk,	State North Carolina	Zip Code 27949

Program Description, Equations, Variables, etc.

This algorithm computes the depth-limited breaking wave height at a structure for design purposes. It can be used in lieu of Figure 7-4 of the Shore Protection Manual. The equation for the curves in Figure 7-4 is not given in the SPM but can be found by simultaneous solution of SPM equations (2-91), (2-92), (2-93), (7-3), and (7-4). Input is wave period, T, and water depth at the structure toe, d_s. The development of the equation is derived on the solution sheet included with program 104R. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I and II, Chs. 2 and 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977.

Operating Limits and Warnings

104A-1

User Instructions

Program Title: 104A Depth-Limited Design Breaking Wave Height at structure

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	ENTER BOTTOM SLOPE m(tangent)	m	A		M
2	ENTER depth AT STRUCTURE ds(ft OR METERS)	ds	B		ds
3	ENTER WAVE PERIOD T (SEC)				
	PRESS E FOR ENGLISH UNITS	for (ft)	E		
	PRESS E' FOR METRIC UNITS	for (m)	E'		
4	READ H_b IN DISPLAY				Hb(ft)
5	FOR NEW T GO TO STEP 3				OR
	NOTE: WITH PRINTER m, ds, T, Hb ARE				Hb(M)
	PRINTED AND LABELED				
	EXAMPLE: ds = 10 ft, T = 10 SEC, m = 0.10				
1	ENTER m = 0.1 PRESS A	0.10	A		0.10
2	ENTER ds = 10 ft PRESS B	10 ft	B		10
3	ENTER T = 10 SEC PRESS E	10 SEC	E		
4	READ Hb = 17.98 IN DISPLAY				17.98
	PRINTOUT FROM EXAMPLE				
	0.1 M				
	10. DS				
	10. T				
	17.98182955 HB				

104A-2

Program Listing

STEP	KEY ENTRY	KEY CODE		COMMENTS
000	LBL	76		
001	A	11		
002	STO	42		$M \to R_0$
003	00	00		
004	3	03	*	"M" PRINT CODE
005	0	00	*	
006	OP	69	*	
007	04	04	*	
008	RCL	43	*	
009	00	00	*	
010	OP	69	*	PRINT BOTTOM
011	06	06	*	SLOPE M
012	R/S	91		
013	LBL	76		
014	B	12		
015	STO	42		$d_s \to R_7$
016	07	07		
017	1	01	*	"DS" PRINT CODE
018	6	06	*	
019	3	03	*	
020	6	06	*	
021	OP	69	*	
022	04	04	*	
023	RCL	43	*	
024	07	07	*	
025	OP	69	*	PRINT d_s
026	06	06	*	
027	R/S	91		
028	LBL	76		E' ALLOWS METRIC
029	E'	10		DATA ENTRY
030	STO	42		$T \to R_9$
031	09	09		
032	9	09		
033	.	93		g = 9.81
034	8	08		
035	1	01		
036	STO	42		$g \to R_8$
037	08	08		
038	3	03	*	
039	0	00	*	
040	OP	69	*	
041	04	04	*	
042	OP	69	*	PRINT "M" TO
043	05	05	*	INDICATE METRIC
044	D'	19		
045	LBL	76		
046	E	15		E - ALLOWS ENGLISH
047	STO	42		DATA ENTRY
048	09	09		$T \to R_9$
049	3	03		
050	2	02		$g = 32.2$ ft/sec^2
051	.	93		
052	2	02		
053	STO	42		$g \to R_8$
054	[illegible]	[illegible]		
055	LBL	76		
056	D'	19		
057	3	03	*	"T" PRINT CODE
058	7	07	*	
059	OP	69	*	
060	04	04	*	
061	RCL	43	*	
062	09	09	*	
063	OP	69	*	PRINT T
064	06	06	*	
065	RCL	43		
066	07	07		
067	÷	55		
068	RCL	43		
069	08	08		
070	÷	55		
071	RCL	43		
072	09	09		
073	X²	33		
074	=	95		
075	STO	42		$\frac{d_s}{gT^2} \to R_1$
076	01	01		
077	RCL	43		
078	00	00		
079	×	65		
080	1	01		
081	9	09		
082	=	95		
083	+/-	94		
084	INV	22		
085	LNX	23		
086	+/-	94		
087	+	85		
088	1	01		
089	=	95		
090	×	65		
091	4	04		
092	3	03		
093	.	93		
094	7	07		
095	5	05		$43.75(1-e^{-19m})$
096	=	95		
097	STO	42		$\to R_3$
098	03	03		
099	RCL	43		
100	00	00		
101	×	65		
102	1	01		
103	9	09		
104	.	93		
105	5	05		
106	=	95		
107	+/-	94		

104A-3

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STEP	KEY ENTRY	KEY CODE	COMMENTS
108	22	INV	
109	23	LNX	
110	85	+	
111	01	1	
112	95	=	
113	55	÷	
114	01	1	
115	93	.	
116	05	5	
117	06	6	
118	95	=	$\frac{1.56}{(1+e^{-19.5m})} = b$
119	35	1/X	
120	42	STO	
121	04	04	$\rightarrow R_4$
122	04	4	
123	75	-	
124	43	RCL	
125	00	00	
126	65	×	
127	09	9	
128	93	.	
129	02	2	
130	05	5	
131	95	=	
132	65	×	
133	43	RCL	
134	00	00	
135	95	=	$m\tau_p = (4-9.25m)m$
136	42	STO	
137	05	05	$\rightarrow R_5$
138	65	×	
139	43	RCL	
140	04	04	
141	75	-	
142	43	RCL	
143	03	03	
144	65	×	
145	43	RCL	
146	01	01	
147	75	-	
148	01	1	
149	95	=	$m\tau_p b - a\hat{d}_s - 1$
150	42	STO	
151	06	06	$\rightarrow R_6$
152	33	X²	
153	85	+	
154	04	4	
155	65	×	
156	43	RCL	
157	03	03	
158	65	×	
159	43	RCL	
160	04	04	
161	65	×	

STEP	KEY ENTRY	KEY CODE	COMMENTS
162	43	RCL	
163	05	05	
164	65	×	
165	43	RCL	$4am\tau_p b\hat{d}_s$
166	01	01	
167	95	=	
168	34	√X	
169	85	+	
170	43	RCL	$((R_6)^2+4am\tau_p)^{1/2}$
171	06	06	
172	95	=	
173	55	÷	
174	53	(	
175	02	2	
176	65	×	
177	43	RCL	
178	03	03	
179	65	×	
180	43	RCL	
181	05	05	$\hat{H}_b = \frac{H_b}{gT^2}$
182	95	=	
183	55	÷	
184	43	RCL	
185	01	01	
186	65	×	
187	02	2	*
188	03	3	* "HB" PRINT CODE
189	01	1	*
190	04	4	*
191	69	OP	*
192	04	04	*
193	43	RCL	
194	07	07	
195	95	=	H_b
196	69	OP	*
197	06	06	* PRINT H_b
198	98	ADV	*
199	91	R/S	

104A-4

* - DELETE IF PRINTER IS NOT AVAILABLE

Program Description

Program Title 105R Wave Transmission - Fuchs' Equation (RPN logic)

Name T.L. Walton, Jr. **Date** 10/80

Address Coastal Engineering Research Center
Kingman Building

City Fort Belvoir, **State** Virginia **Zip Code** 22060

Program Description, Equations, Variables, etc.

This algorithm computes wavelength, L, in water depth, d, given the wave period, T. The program then computes wave transmission over a thin vertical barrier in water depth, d, using Fuchs' equation:

$$\frac{H_t}{H_i} = \sqrt{1 - \frac{\frac{4\pi h}{L} + \sinh\frac{4\pi h}{L}}{\frac{4\pi d}{L} + \sinh\frac{4\pi d}{L}}}$$

where H_t is the transmitted wave height, H_i the incident wave height, and h the height of barrier. Note that this equation *cannot* be used when wave transmission is by overtopping of a structure. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. II, Ch. 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, p. 7-62.

Operating Limits and Warnings

105R-1

User Instructions

Program Title: 105R Wave Transmission - Fuchs' Equation

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	ENTER WATER DEPTH d IN FEET OR	d (FT) OR			
	METERS, READ 2πd IN DISPLAY	d (M)	A		2πd
2	ENTER SILL HEIGHT h IN FEET	h (FT) OR			
	OR METERS	h (m)	B		
3	ENTER WAVE PERIOD T (SECONDS)	T (SEC)			
4	PRESS E FOR ENGLISH UNITS		E		
	PRESS f e FOR METRIC UNITS		f	e	
5	READ L (IN FEET OR METERS)				L
6	PRESS R/S		R/S		
7	READ HT/Hi				HT/Hi
8	TO REPEAT FOR NEW T GO TO				
	STEP 3				
	EXAMPLE :				
	d = 15 FT, h = 10 FT., T = 10 SEC				
	ENTER d = 15, PRESS A	15 FT	A		
	ENTER h = 10, PRESS B	10 FT	B		
	ENTER T = 10, PRESS E	10 SEC	E		
	READ L = 213.02 FT.				213.02
	PRESS R/S, READ HT/Hi = 0.60		R/S		0.60

105R-2

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	ENTER d		RCL 3	34 03	
	ENTER	41			+	61	
	2	02			2	02	
	x	71		060	÷	81	
	h π	35 73			STO 2	33 02	$L_{NEW} \rightarrow R_2$
	x	71			RCL 3	34 03	
	STO 0	33 00	$2\pi d \rightarrow R_0$		—	51	
	R/S	84			h ABS	35 64	
	f LBL B	31 25 12	ENTER h		1	01	
010	STO 8	33 08			g x > y	32 81	
	R/S	84			GTO f c	22 31 13	
	g LBL f e	32 25 15			RCL 2	34 02	
	STO 7	33 07	$T \rightarrow R_7$		GTO f d	22 31 14	
	9	09		070	g LBL f c	32 25 13	
	.	83			RCL 2	34 02	
	8	08			R/S	84	L IN DISPLAY
	1	01			h 1/x	35 62	
	STO 6	33 06	g(METRIC) $\rightarrow R_6$		RCL 0	34 00	
	GTO f b	22 31 12			x	71	
020	f LBL E	31 25 15			2	02	
	STO 7	33 07	$T \rightarrow R_7$		x	71	
	3	03			STO 6	33 06	$\frac{4\pi d}{L} \rightarrow R_6$
	2	02			f GSB 1	31 22 01	
	.	83		080	RCL 6	34 06	
	2	02			+	61	
	STO 6	33 06	g(ENGLISH) $\rightarrow R_6$		STO 7	33 07	$R_6 + \sinh(R_6) \rightarrow R_7$
	g LBL f b	32 25 12			4	04	
	RCL 7	34 07			ENTER	41	
	g x^2	32 54			h π	35 73	
030	RCL 6	34 06			x	71	
	x	71			RCL 8	34 08	
	2	02			x	71	
	÷	81			RCL 2	34 02	
	h π	35 73		090	÷	81	
	÷	81			STO 9	33 09	$\frac{4\pi h}{L} \rightarrow R_9$
	STO 1	33 01	$L_0 \rightarrow R_1$		f GSB 1	31 22 01	
	g LBL f d	32 25 14			RCL 9	34 09	
	STO 3	33 03	$L_{OLD} \rightarrow R_3$		+	61	
	h 1/x	35 62			RCL 7	34 07	
040	RCL 0	34 00			÷	81	
	x	71			CHS	42	
	STO 4	34 04	$\frac{2\pi d}{L_{OLD}} \rightarrow R_4$		1	01	
	g e^x	32 52			+	61	
	RCL 4	34 04		100	f $\sqrt{x}$	31 54	
	CHS	42			R/S	84	H_T/H_i IN DISPLAY
	g e^x	32 52			f LBL 1	31 25 01	
	—	51			STO 5	33 05	
	RCL 4	34 04			g e^x	32 52	
	g e^x	32 52			RCL 5	34 05	
050	RCL 4	34 04			CHS	42	SINH SUBROUTINE
	CHS	42			g e^x	32 52	
	g e^x	32 52			—	51	
	+	61			2	02	
	÷	81	$\tanh \frac{2\pi d}{L_{OLD}}$	110	÷	81	
	RCL 1	34 01			h RTN	35 22	
	x	71					

105R-3

Program Description

Program Title 105A Wave Transmission - Fuchs' Equation (AOS logic)
Name W.A. Birkemeier **Date** 5/81
Address CERC Field Research Facility
City Kitty Hawk, **State** North Carolina **Zip Code** 27949

Program Description, Equations, Variables, etc.

This algorithm computes wavelength, L, in water depth, d, given the wave period, T. The program then computes wave transmission over a thin vertical barrier in water depth, d, using Fuchs' equation:

$$\frac{H_t}{H_i} = \sqrt{1 - \frac{\frac{4\pi d}{L} + \sinh \frac{4\pi d}{L}}{\frac{4\pi d}{L} + \sinh \frac{4\pi d}{L}}}$$

where H_t is the transmitted wave height, H_i the incident wave height, and h the height of barrier. Note that this equation *cannot* be used when wave transmission is by overtopping of a structure. Algorithm uses English or metric system of units.

REFERENCE

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vol. II, Ch. 7, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, p. 7-62.

Operating Limits and Warnings

105A-1

User Instructions

Program Title: 105A Wave Transmission - Fuchs' Equation

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	ENTER WATER DEPTH (d) IN FEET OR METERS	d(ft) or			
		d(m)		A	d
2	ENTER SILL HEIGHT (h) IN FEET OR METERS	h(ft) or			
	(WITH PRINTER, LABEL READS SH FOR SILL HEIGHT)	h(m)		B	h
3	ENTER WAVE PERIOD T (SEC)				
	PRESS E FOR ENGLISH UNITS	T(SEC)		E	
	PRESS E' FOR METRIC UNITS	T(SEC)		E'	
4	WITH PRINTER Lo, L, Ht/Hi ARE PRINTED				Lo
	AND LABELED. Lo AND L ARE COMPUTED IN				L
	INPUT UNITS. WITHOUT PRINTER:				Ht/Hi
	READ Lo				Lo
	PRESS R/S READ L			R/S	L
	PRESS R/S READ Ht/Hi			R/S	Ht/Hi
5	TO REPEAT FOR NEW T GO TO STEP 3				
	EXAMPLE				
	d = 15 ft , h = 10 ft , T = 10 SEC				
	ENTER d = 15 PRESS A	15 ft	A		15
	ENTER h = 10 PRESS B	10 ft	B		10
	ENTER T = 10 PRESS E	10 SEC	E		10
	READ Lo = 512.48				512.48
	PRESS R/S (if REQUIRED) READ L = 213.02				213.02
	PRESS R/S (if REQUIRED) READ Ht/Hi				0.598
	PRINTOUT OF EXAMPLE				
	15. D				
	10. SH				
	10. T				
	512.4789168 LO				
	213.0238318 L				
	0.597721319 H/H				

105A-2

Program Listing

STEP	KEY ENTRY	KEY CODE		COMMENTS
000	76	LBL		
001	11	A		
002	42	STO		$d \to R_0$
003	00	00		
004	65	×		
005	01	1	*	
006	06	6	*	"D" PRINT CODE
007	69	OP	*	
008	04	04	*	
009	02	2		
010	65	×		
011	89	π		
012	95	=		
013	48	EXC		$2\pi d \to R_0$
014	00	00		
015	69	OP	*	PRINT d
016	06	06	*	
017	91	R/S		
018	76	LBL		
019	12	B		
020	42	STO		$h \to R_8$
021	08	08		
022	03	3	*	
023	06	6	*	"SH" PRINT CODE
024	02	2	*	(SILL HEIGHT)
025	03	3	*	
026	69	OP	*	
027	04	04	*	
028	43	RCL	*	
029	08	08	*	
030	69	OP	*	
031	06	06	*	PRINT h
032	91	R/S		
033	76	LBL		STEPS 33 TO 49
034	10	E'		ALLOW METRIC
035	42	STO		INPUT/OUTPUT
036	07	07		$T \to R_7$
037	09	9		
038	93	.		g= 9.81
039	08	8		
040	01	1		
041	42	STO		$g \to R_6$
042	06	06		
043	03	3	*	"M" PRINT CODE
044	00	0	*	
045	69	OP	*	PRINT "M" TO
046	04	04	*	INDICATE METRIC
047	69	OP	*	
048	05	05	*	
049	17	B'		
050	76	LBL		STEPS 50 TO 59
051	15	E		ALLOW ENGLISH
052	42	STO		INPUT/OUTPUT
053	07	07		$T \to R_7$
054	03	3		
055	02	2		
056	93	.		
057	02	2		
058	42	STO		$g \to R_6$
059	06	06		
060	76	LBL		
061	17	B'		
062	03	3	*	"T" PRINT CODE
063	07	7	*	
064	69	OP	*	
065	04	04	*	
066	43	RCL		
067	07	07		
068	69	OP	*	PRINT T
069	06	06	*	
070	33	X^2		
071	65	×		
072	43	RCL		
073	06	06		
074	55	÷		
075	02	2		
076	55	÷		
077	02	2	*	"L_0" PRINT CODE
078	07	7	*	
079	03	3	*	
080	02	2	*	
081	69	OP	*	
082	04	04	*	
083	89	π		
084	95	=		
085	42	STO		$L_0 \to R_1$
086	01	01		
087	69	OP	*	PRINT L_0
088	06	06	*	
R/S → 089	76	LBL		
090	14	D		
091	01	1		
092	32	X⇌T		
093	43	RCL		
094	01	01		
095	76	LBL		
096	19	D'		
097	42	STO		$L_{OLD} \to R_3$
098	03	03		
099	35	1/X		
100	65	×		
101	43	RCL		
102	00	00		
103	95	=		
104	42	STO		$\frac{2\pi d}{L_{OLD}} \to R_4$
105	04	04		
106	22	INV		
107	23	LNX		
108	75	-		
109	48	EXC		

*- DELETE IF PRINTER IS NOT AVAILABLE
R/S- INSERT IF PRINTER IS NOT AVAILABLE

105A-3

STEP	KEY ENTRY	KEY CODE	COMMENTS
110	04	04	
111	94	+/-	
112	22	INV	
113	23	LNX	
114	42	STO	
115	05	05	
116	95	=	
117	55	÷	
118	53	(	
119	43	RCL	
120	04	04	
121	85	+	
122	43	RCL	
123	05	05	
124	95	=	tanh $2\pi d/L_{old}$
125	65	×	
126	43	RCL	
127	01	01	
128	85	+	
129	43	RCL	
130	03	03	
131	95	=	
132	55	÷	
133	02	2	
134	95	=	
135	42	STO	$L_{NEW} \rightarrow R_2$
136	02	02	
137	75	-	
138	43	RCL	$L_{NEW} - L_{OLD}$
139	03	03	
140	95	=	
141	50	I×I	
142	22	INV	
143	77	GE	ITERATE TO COMPUTE L
144	18	C'	
145	43	RCL	
146	02	02	
147	19	D'	
148	76	LBL	
149	18	C'	
150	02	2 *	"L" PRINT CODE
151	07	7 *	
152	69	OP *	
153	04	04 *	
154	43	RCL	
155	02	02	
156	69	OP *	PRINT L
157	06	06 *	
R/S → 158	35	1/X	
159	65	×	
160	43	RCL	
161	00	00	
162	65	×	
163	02	2	
164	95	=	
165	42	STO	$4\pi d/L \rightarrow R_6$
166	06	06	
167	71	SBR	
168	38	SIN	sinh $\left(\frac{4\pi d}{L}\right)$
169	85	+	
170	43	RCL	
171	06	06	
172	95	=	
173	42	STO	$4\pi d/L + \sinh\left(\frac{4\pi d}{L}\right)$
174	07	07	
175	04	4	$\rightarrow R_7$
176	65	×	
177	89	π	
178	65	×	
179	43	RCL	
180	08	08	
181	55	÷	
182	43	RCL	
183	02	02	
184	95	=	
185	42	STO	$4\pi h/L \rightarrow R_9$
186	09	09	
187	71	SBR	
188	38	SIN	sinh $\left(\frac{4\pi h}{L}\right)$
189	85	+	
190	43	RCL	$\frac{4\pi h}{L} + \sinh\left(\frac{4\pi h}{L}\right)$
191	09	09	
192	95	=	
193	55	÷	
194	43	RCL	
195	07	07	
196	95	=	
197	94	+/-	
198	85	+	
199	02	2 *	
200	03	3 *	"H/H" PRINT CODE
201	06	6 *	
202	03	3 *	
203	02	2 *	
204	03	3 *	
205	69	OP *	
206	04	04 *	
207	01	1	
208	95	=	
209	34	√X	
210	69	OP *	
211	06	06 *	PRINT H_t/H_i
212	98	ADV *	
213	91	R/S	
214	76	LBL	STEPS 214 TO 235 COMPUTE sinh (R_{11})
215	38	SIN	
216	42	STO	
217	11	11	
218	22	INV	
219	23	LNX	

105A-4

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS

```
220  48 EXC
221  11  11
222  94 +/-
223  22 INV
224  23 LNX
225  94 +/-
226  85  +
227  43 RCL
228  11  11
229  95  =
230  55  ÷
231  02  2
232  95  =
233  92 RTN
```

130

140

150

160

170

180

190

200

210

220

105A-5

APPENDIX

BLANK PROGRAM FORMS

Program Description

Program Title		
Name		**Date**
Address		
City	State	Zip Code
Program Description, Equations, Variables, etc.		
Operating Limits and Warnings		

User Instructions

Program Title

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS

Program Listing

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001							
				060			
010							
				070			
020							
				080			
030							
				090			
040							
				100			
050							
				110			

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
				170			
120							
				180			
130							
				190			
140							
				200			
150							
				210			
160							
				220			

Walton, Todd L. (Todd Leon)
Hand-held calculator algorithms for coastal engineering / by Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel.--Fort Belvoir, Va. : U.S. Army Coastal Engineering Research Center ; Springfield, Va. : available from NTIS, 1982.
[71] p. : forms ; 28 cm.--(Coastal engineering technical aid ; no. 82-1). Cover title.
"January 1982."
Report provides algorithms for a number of calculator programs useful in performing coastal engineering calculations, primarily in the area of wave transformations and wave generation. Six programs are included with different versions for use with hand-held calculators which employ either the Reverse Polish Notation (RPN) or the Algebraic Operating System (AOS).
1. Coastal engineering--Data processing. 2. Calculating-machines. 3. Algorithms. 4. Wave transformation--Data processing. 5. Wave generation--Data processing. I. Birkemeier, William A. II. Weggel, J. Richard (John Richard), 1941. III. Title. IV. Series.
TC203 .U581ta no. 82-1 627

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Hand-held calculator algorithms for coastal engineering / by Todd L. Walton, Jr., William A. Birkemeier, and J. Richard Weggel.--Fort Belvoir, Va. : U.S. Army Coastal Engineering Research Center ; Springfield, Va. : available from NTIS, 1982.
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DATE

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